ANNALS
OF
The Entomological Society of America

Volume XXXV DECEMBER, 1942 No. 4

A REMARKABLE NEW HELIODINID (MICROLEPIDOPTERA)

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The discovery of a second species of the previously monotypic South American genus *Cyphacma* Meyrick, with characters which show that genus to be closely allied to *Cycloplasis* Clemens, suggests a discussion of the described species of these two genera, which form an interesting phylogenetic series, separated from the rest of the Heliodinidae by the greatly reduced venation and the obtect pupa.

Cyphacma Meyrick

Cyphacma Meyrick, Trans. Ent. Soc. Lond., 1915, p. 213.

The genus, erected for the single species, *chalcozela*, from Colombia, Ecuador and Peru, was characterized as follows:

"Head smooth; ocelli present; tongue short. Antennae ¾, in male simple, basal joint elongate, without pecten. Labial palpi long, slender, filiform, curved, ascending, terminal joint somewhat shorter than second, pointed. Maxillary palpi obsolete. Posterior tibiae with rough projecting bristly hairs above, tarsi with very short bristles at apex of joints. Forewings with apex strongly bent down as though deformed; 1b simple, 2 from angle, 3–5 absent, 6 and 8 stalked, 7 absent, 9 out of 8 near base, cell open between 9 and 10, 11 from middle. Hindwings ⅓, linear-lanceolate, cilia 6; 3–5 absent, cell open between 2 and 6, 6 and 7 connate."

In a letter two years later Mr. Meyrick wrote: "Above is a sketch of the forewing of *Cyphacma* [herewith reproduced as fig. 2]; I think 5 is present as marked, not absent as stated, but these apical veins are very slight and faint."

Following the specific description of *C. chalcozela* is this statement: "This is a very singular little insect; the deflexed

apex of forewing (giving a bluntly rounded convex aspect very different to its real shape as seen when denuded and flattened out) and metallic brilliance suggest that in life there must be considerable resemblance to a small Phytophagous Coleopteron."

The species described below as *Cyphacma tragiae*, new species, agrees closely with the genotype in venation, but differs from Meyrick's generic description in several other points, these points being just those in which *Cyphacma tragiae* approaches or agrees with *Cycloplasis*.

Specifically, *Cyphacma tragiae* differs from *C. chalcozela* in the black basal half of fore wing with silvery transverse mark.

Cyphacma tragiae, n. sp.

Head and thorax lustrous silvery metallic; the head behind with a raised frill of black scales (as in *Cycloplasis*); palpi grayish, rather short, but little curved, divergent, the third segment a little longer than the second and terminated by four expansible spines, which when appressed form the acute apex. Antennae about 2/3, the first segment but slightly more elongate than the corresponding segment in *Cycloplasis*. Fore wings arched, with surface convex and apex deflexed, black in basal half, shading to a grayish blue metallic color in outer half, with very elongate bluish metallic scales overlapping the black cilia. Just within the costal edge, at one-third the wing length, a silvery metallic, slightly inwardly oblique bar extends to the fold, or occasionally just beyond it, or may be reduced to a nearly circular spot next to costa. Hind wings and cilia nearly black. Legs black, with base and a broad band nearly to apex of posterior tibiae silvery, some of spines silvery. Abdomen silvery at base above, black toward tip; silvery beneath. Expanse: 4.8 to 5.6 mm.

Type—♂, near Cedar Creek, Jefferson County, Kentucky, reared (B. 1832) from a miner of leaves of *Tragia macrocarpa* Willd. (*T. cordata* Michx.) (Euphorbiaceae), imago May 6, 1941.

Paratypes—1 ♂, emerged August 5, 1940; 2 ♂'s, emerged May 6 and June 1, respectively, 1941; 1 ♀, August 5, 1940; 2 ♀'s, May 6 and May 8, respectively, 1941, all from Cedar Creek, Jefferson County, Kentucky; 1 ♂, emerged September 12, 1941, Mammoth Cave, Kentucky, all reared on *Tragia* under record number B. 1832.

For the present, all type material is in the collection of the author.

The completed mine (Fig. 5) is linear throughout and irregularly branched, with the aspect of a Dipterous mine. At its beginning the mine is a minute, somewhat circular blotch, with the frass in a patch in the middle. Remnants of the egg may be seen more or less distinctly

at the margin or on the blotch, usually on the upper side of the leaf. The egg is flat and appears to be pressed into the leaf tissue. From the blotch, the first linear gallery starts out, and where not obliterated by the later irregular branching of the mine, may be recognized as much narrower than the rest of the mine. In making a new branch, the larva turns back a short distance before turning out from the older mine; this branch may in turn be branched, but more often the larva

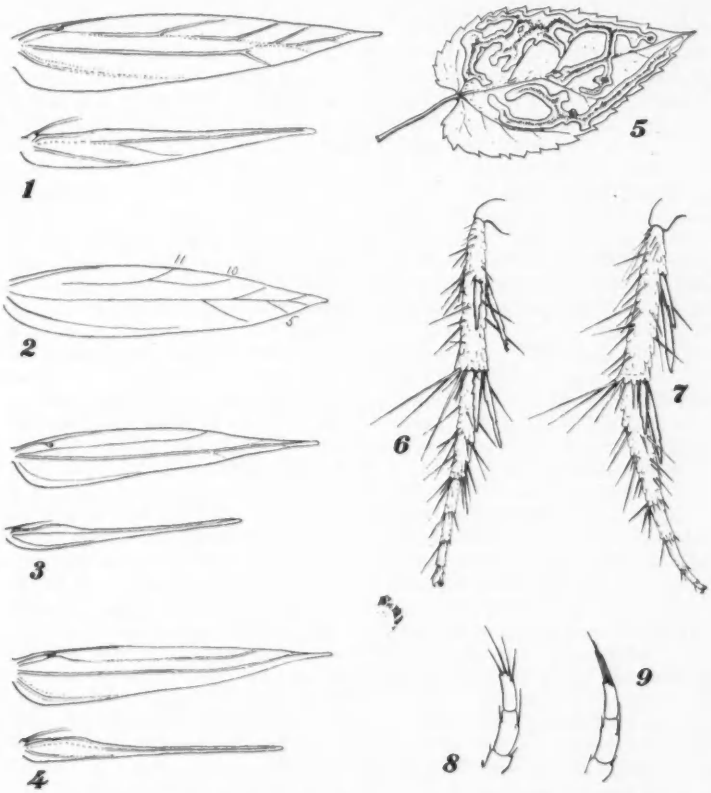

FIG. 1. Venation of *Cyphacma tragiae* n. sp. 2. Venation of fore wing of *Cyphacma chalcozela* Meyrick (after Meyrick). 3. Venation of *Cycloplasis habrarcha* Meyrick (drawing constructed from description). 4. Venation of *Cycloplasis panicifoliella* Clemens. 5. Leaf with three mines: one below; two above crossing one another as shown by the two eggs and first blotches (about natural size). 6. Posterior tibia and tarsus of *Cycloplasis panicifoliella*. 7. Posterior tibia and tarsus of *Cyphacma tragiae* n. sp. 8. Labial palpus of *Cycloplasis panicifoliella* with apical spines spread. 9. The same with apical spines appressed together.

returns again to the older mine. The frass is deposited along the middle of the mine. The parenchyma in the mine is to a great extent consumed. A leaf may contain several mines, crossing one another and running together.

The larva is pale, greenish while feeding, whitish after leaving the mine; head pale luteous, scarcely darker than the body, mandibles dark brown; prothoracic shield pale luteous, trapezoidal, but with sides slightly concave, anterior margin convex, and anterior angles acutely produced laterally; a similar chitinous plate on the ventral surface of the first thoracic segment, very pale and nearly concolorous with the rest of the body. Setae present. The three pairs of thoracic legs are present, the first pair very small; prolegs present on abdominal segments 3, 4, 5, 6 and 10, functional, but not well developed. Compare this with the much more specialized larva of *Cycloplasis panicifoliella* which does not leave the mine (Dyar, Proc. Ent. Soc. Wash., 1901, Vol. IV, p. 479).

When full grown, the larva leaves the mine, and spins a broadly oval cocoon, of dense, pure white, almost cobwebby silk. From the cocoon, a few frothy globules are sometimes ejected. In emergence, the pupa is not protruded from the cocoon. Pupa obtect, the first four segments fixed, followed by three movable incisures; spiracles borne on slender cones; no dorsal spines, but each abdominal segment with a pair of short curved setae ventral to the spiracles; cremaster with three pairs of hooked setae. Appendages free from the body caudad of the fourth segment; wings reaching onto the sixth segment, separated toward tip exposing posterior tarsi. Maxillae concealing the labial palpi except for a minute triangular basal piece; maxillary palpi present, but extremely minute. Antennae short, not reaching tip of exposed part of mesothoracic legs. Front legs touching antennae at base, front femora exposed.

Mining larvae may be found throughout the summer and early autumn, apparently with no definite broods distinguishable. In August and September miners of all ages may be found at the same time. Emergence of the imagoes seems to be determined by temperature conditions; a hot spell may result in emergence of some imagoes, while others remain over for varying periods. Thus the imagoes of early May and June 1 came from the same lot of larvae, collected September 3 of the preceding year, those of August 5 from larvae full-fed on July 24, the imago of September 12 from larvae collected August 19, while the rest of the pupae from this collection remained over winter. This apparent dependence on warmth for emergence results in a high mortality amongst the reared material when in the pupal state.

The natural range of the food plant, as given in Britton and Brown's Illustrated Flora is "Kentucky to Missouri, Florida and Mexico." In general the genus is of tropical distribution.

The imago rests with the hind legs elevated and prominently displayed; the wings arched with the upper surface convex, the tips of the wings curved downward. The moth more often jumps than flies; this habit, with the convex wing surface and conspicuous hind legs, gives it the aspect of a minute flea beetle.

In venation, *Cyphacma tragiae* and *C. chalcozela* agree (compare figs. 1 and 2) except that in the fore wing of *C. tragiae* (fig. 1) the cell is closed between veins 9 and 10 by an obsolescent vein (the basal portion of R_3). The obsolescence of the base of the radial sector in *C. tragiae* foreshadows its complete disappearance together with R_2 and the basal piece of R_3 in all species of *Cycloplasis* (figs. 3 and 4). In the hind wing, vein 6 (M_1) is weak in *Cyphacma tragiae*, but the evenly tapering hind wing at once distinguishes *Cyphacma* from *Cycloplasis*. Loss of this vein and the extreme narrowing of all but the base of the wings will bring about the condition seen in *Cycloplasis*. Apparently intermediate between *Cyphacma* and the two North American species of *Cycloplasis* in venation of fore wing, is the South American *Cycloplasis habrarcha* Meyrick. Figure 3, constructed from Meyrick's description of the venation of this species (Exot. Microlep., II, 64, 1917), gives my interpretation of the venation of this species based on the assumed relationship of *Cyphacma* and *Cycloplasis*. On this basis, the strong vein through the middle of the fore wing in the two North American species of *Cycloplasis* (fig. 4) is composed of the lower margin of the cell (Cu_1), the discal vein, and the stalk of the remaining branches of Media and Radius. In fact, in both *Cycloplasis panicifoliella* Clemens and *Cycloplasis immaculata* Braun, there is a slight irregularity or break in this vein just at the point where vein 2 (Cu_{1b}) would be given off (fig. 4). Hence the interpretation of the venation by Forbes (Lepidoptera of New York and Neighboring States, 1923, p. 359) is not tenable.

In palpal structure, *Cyphacma tragiae* agrees with *Cycloplasis*, and is at variance with the description given in Meyrick's generic characterization. The spines at the tip of the third segment when closely appressed together appear as a small acute segment, and may have been mistaken for the third segment. This is indicated by Meyrick's description of the third segment of the palpi in *Cycloplasis habrarcha* as very short and pointed; the third segment together with its apical spines is considerably longer than the second in *Cycloplasis*. Figure 8 shows the labial palpus of *Cycloplasis panicifoliella* with spines spread; fig. 9 with spines appressed together. Both conditions may be observed in dry specimens. Minute maxillary palpi are present in both genera.

In spining of the posterior tibiae and tarsi *Cyphacma tragiae* (fig. 7) shows a condition intermediate between *Cycloplasis* (fig. 6) and that described for *Cyphacma chalcozela*, in which the posterior tarsi are described as having "very short bristles at apex of joints," with no mention of spines on the first segment, present in *Cyphacma tragiae*.

Two more species of *Cycloplasis* not discussed here have een described: *gnathodes* Meyrick (Exot. Microlep., II, 64, 917) from Ecuador, and *basiplagata* Wlsm. (Proc. Zool. Soc. ond., 1897, p. 143) from the West Indies; no information as to ructure of either is available. The food plant of the latter given as *Sida* sp. (Malvaceae), but the larval habit as

described seems doubtful; the case may be the pupal rather than the larval case, and cut from the leaf as in the grass-mining species.

The more complete venation, together with the broader and evenly tapering hind wings, the different larval habits and larval structure at once separate *Cyphacma* from *Cycloplasis*. The points of similarity, not shared by any other genera in the Heliodinidae, indicate their close relationship, and suggest the possibility of further connecting forms.

MILITARY PREVENTIVE MEDICINE, by GEORGE C. DUNHAM. xxvi+1198 pp., 329 illustrations, 2 colored plates. Buckram binding. Third edition. 1940. MILITARY PUBLISHING CO., 100 Telegraph Bldg., Harrisburg, Pa. Price $3.75.

Many biologists are now serving in our military organizations in the capacity of entomologists, and individuals with the proper training are being successful in giving service of importance, the value of which is recognized. There are entomologists and students in college, lacking the essential training, who, upon being called into service, will try to get into entomological work. This book by Brigadier General Dunham is of great importance to the latter groups. It is unique in that it gives the medical officers' conception of the relation and importance of medical entomology to other phases of preventive medicine in connection with a military force. Because of this fact alone, anyone contemplating military service as an entomologist or general sanitarian or engaged in teaching people who may do this sort of work, should study this volume with care.

Five chapters of approximately 200 pages contain brief and accurate accounts of insects and insect-borne diseases troublesome to troops. The biology and control of insects are stressed; general principles receive special attention. Since this book deals primarily with the prevention of epidemics, the protection of groups of men rather than of individuals is emphasized. There is very little information for the identification of specimens. The poisonous and venomous arthropods are not included. The chapter on rat control, a job which entomologists often find passed on to them, is worthwhile. This volume is not a comprehensive treatise on medical entomology but, as pointed out above, its value is of great importance. The price quoted was obtained from a local bookstore and we believe it is correct.—C. E. VENARD.

A DESCRIPTIVE STUDY OF THE PILOTAXY OF A MODAL CULEX PIPIENS FOURTH STAGE LARVA

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This paper is a descriptive study of the larval pilotaxy of a stenogamous, autogenous strain of *Culex pipiens* from the laboratory in the department of Bacteriology and Parasitology at the University of Chicago. The study was initiated by observations on a mounted fourth instar larva which was then described and drawn. One hundred additional mounted larvae, constituting a random sample, were examined and the findings were tabulated. The result is given here as the description of the pilotaxy of a modal fourth-stage larva.

TYPES OF HAIRS

The illustration of the complete larva (figure 1) shows a number of different types of hairs. A hair may be single, unbranched; bifid, divided at the base into two branches; or tufted, divided at the base into three or more branches. An unusual dendroid type of hair, occurring in not more than four positions on the whole larva, is branched and rebranched at many points between the base and the distal end. Single hairs and branches of hair tufts vary greatly in length and thickness; they may be simple, with bare surface; barbed; or feathered. Figure 2 illustrates types of hairs.

ARRANGEMENT

The hairs of the larva are in a symmetrically paired arrangement. Only one member of each pair is described here. In figure 1 the left side shows the dorsal hairs of the head, the thorax, and the first seven segments; the right side shows the ventral hairs. A lateral view of the terminal segments is shown.

PILOTAXY OF THE HEAD

The antennae:

Projecting from the spine-studded shaft of the antenna is the antennal hair of approximately twenty heavily feathered branchings. The truncated apex bears two short subterminal setae, two short terminal bristles, and a small chitinous digit.

Dorsal head hairs:

The most anterior hair on the dorsal surface of the head is the short, stout, curved preclypeal spine. On the clypeus, the central portion of the head, the regular designation of hairs by numbers begins. These hairs are in two irregular rows. The anterior row contains the frontal hairs, numbers 2, 3, and 4, which are prominent and important for purposes of identification.

No. 1. A single, slender hair medium short in length, located near the mid dorsal line and slightly anterior to center.

Nos. 2 and 3. Stout hairs, approixmately half the length of the head, with respectively 5 and 4 feathered branchings from the base. Located slightly posterior and lateral to hair number 1.

No. 4. Similar in structure to numbers 2 and 3, with ten feathered branchings. Located anterior and lateral to numbers 2 and 3.

Nos. 5 and 6. Short, fine hairs with 2 and 3 branchings respectively. Located near the base of the head.

No. 7. A single hair of medium length, inserted laterally at the base of the eye.

Ventral head hairs:

Although the mouth-brushes may be seen in a dorsal view of the larva, they are borne by the labrum on the ventral surface. These brushes are composed of a collection of fine, long, curved hairs.

No. 1. The most medial ventral head hair, slightly posterior to center. Very short and fine with 3 branchings.

No. 2. A single, fine, short hair.

Nos. 3, 4, and 5. Numbers 3 and 5 are medium in length. Number 4 is slightly longer and stouter than numbers 3 and 5. Each has 3 branchings. These hairs follow approximately the line of the eye from posterior medial to anterior lateral margin.

PILOTAXY OF THE THORAX

The thorax is divided in hair arrangement into three segments, prothorax, mesothorax, and metathorax. Each segment contains, on the dorsal and ventral surfaces, one irregular row of hairs which includes the lateral hairs. These lateral hairs and the "shoulder" hairs on the anterior margin of the dorsal surface of the prothorax are the most prominent on the larva and are important for identification. All these hairs arise from large papillae.

Dorsum of the prothorax:

No. 1. A group of three "shoulder" hairs inserted individually but in one papilla. Very stout and barbed. These are the longest hairs on the larva. They extend from the anterior margin of the thorax to the front of the head.

Nos. 2, 3, 4, 5 and 6. Inserted in individual papillae. Similar to number 1 but only three-fourths as long. Numbers 3 and 4 are single; numbers 2, 5, and 6 are bifid. These hairs are inserted in a row which follows the contour of the anterior margin of the thorax.

No. 7. A short dendroid type tuft having a varying number of hairs, branched and rebranched from the base to the distal end.

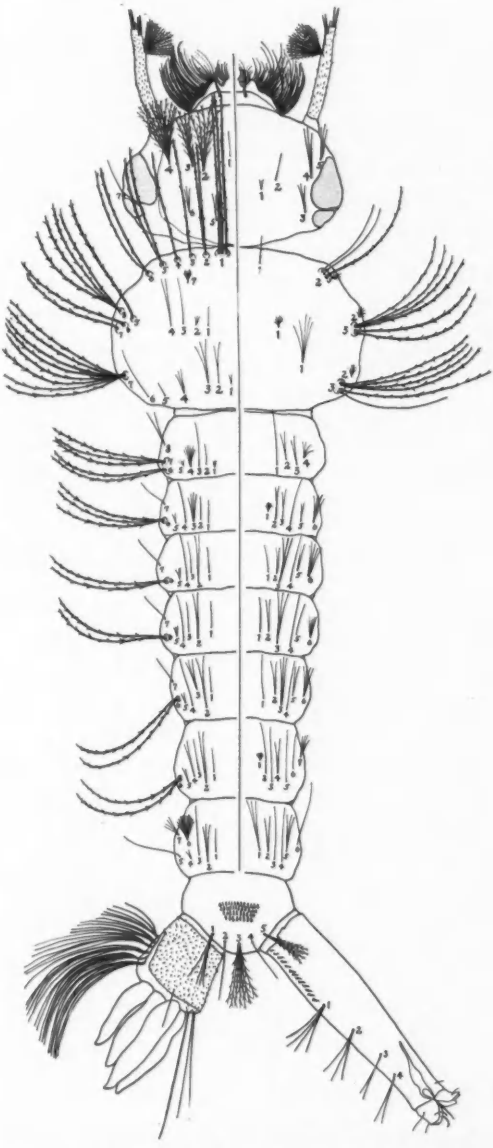

FIG. 1. Pilotaxy of a modal *Culex pipiens* larva. The left side shows the dorsal hairs of the head, the thorax, and the first seven segments; the right side shows the ventral hairs. A lateral view of the terminal segments is shown.

Ventrad of the prothorax:

No. 1. The anterior medial hair, single, short, and slender.

No. 2. A lateral group of four hairs inserted in a large papilla. There are two medium long, slender, simple hairs; one long, stout, barbed hair; and a tuft of very short fine hairs.

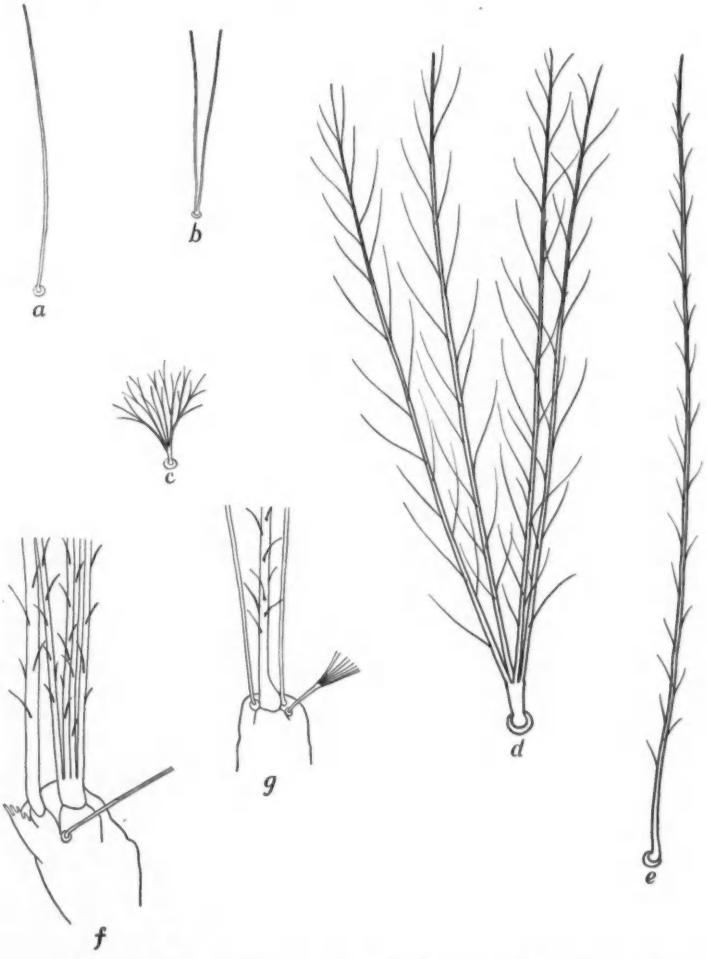

FIG. 2. Pilotaxy of a modal *Culex pipiens* larva. Various types of hairs. (a) simple hair; (b) bifid hair; (c) dendroid type hair; (d) feathered hair with multiple branching; (e) barbed hair. (f) and (g) illustrate insertions of several hairs in single papillae. The hairs illustrated in (f) and (g) are truncated.

Dorsum of the mesothorax:

Nos. 1, 2, 3 and 4 form an irregular row from the medial line to the lateral margin. Number 1 is single and short; number 2 is very short with 3 branchings; number 3 is medium in length and single; number 4 is medium in length and bifid.

Nos. 5, 6, 7 and 8 on the lateral margin are long, stout, and barbed. The first three are single. Numbers 6 and 7 are inserted in the same papilla. Number 8 has 6 branchings.

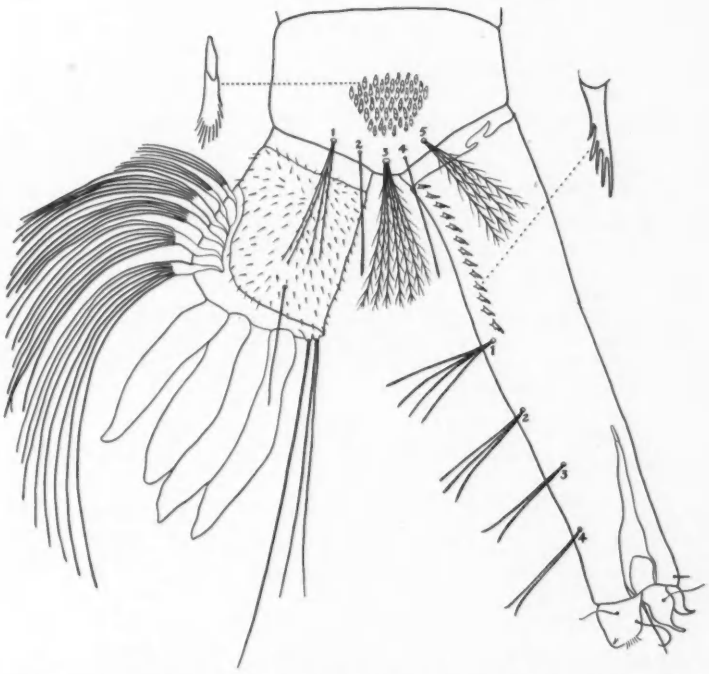

FIG. 3. Pilotaxy of a modal *Culex pipiens* larva. Lateral view of the terminal segments showing an enlarged pecten tooth and scale.

Ventrad of the mesothorax:

No. 1. Similar in all characteristics to number 7 of the dorsum of the prothorax.

No. 2. A tuft of very short, fine hairs on the lateral margin.

No. 3. A lateral group of three long, stout, barbed hairs arising from one papilla. Two are long and single; the other is slightly shorter with 4 branchings.

Dorsum of the metathorax:

Numbers 1 through 6 form an irregular row from the medial line to the lateral margin near the posterior margin of the thorax. Number 1 is very short and bifid; numbers 2 and 3 are medium in length with 2 and 3 branchings respectively; number 4 is short with 3 branchings; number 5 is single and very short; number 6 is single, slender, and medium long.

No. 7. Inserted on lateral margin. Similar to number 8 of the dorsum of the mesothorax but with 8 branchings.

Ventrad of the metathorax:

No. 1. Slender, of medium length, with 5 branchings.

No. 2. A very short tuft of numerous fine hairs.

No. 3. Three hairs arising from a single papilla at the lateral posterior margin of the thorax: one long, stout, barbed hair with 4 branchings; a similar single hair; and one single, simple, slender hair of medium length.

PILOTAXY OF THE FIRST SEVEN ABDOMINAL SEGMENTS

The dorsal and ventral surfaces of each of the first seven abdominal segments contain from 4 to 8 hairs arranged in irregular rows beginning near the medial line and being numbered consecutively from that point to the lateral margin.

Homologies between hairs of succeeding segments have been considered (Hart, 1942), and for convenience the hairs of the dorsum of segments III, IV, V, and VI and of the ventrad of segments III, IV, and V are described collectively.

Dorsum of segment I:

No. 1. A very short hair divided at the base into 3 branches.

No. 2. A short, single hair.

No. 3. Medium long, and simple.

No. 4. A brush of approximately 10 fine, short hairs.

No. 5. A very short, fine hair with 4 branchings.

Nos. 6 and 7. Long, stout, barbed hairs of 2 and 3 branchings, inserted in a single large papilla.

No. 8. Medium in length, slender, bifid.

Ventrad of segment I:

No. 1. Long, slender, single.

Nos. 2 and 3. Medium short, bifid.

No. 4. A short, fine hair with 4 branchings.

Dorsum of segment II:

Nos. 1 and 2 are short and simple.

No. 3. Divided at the base into 4 branches of medium length.

No. 4. A long, slender, single hair.

No. 5. Short, fine, bifid.

No. 6 corresponds in character and position to number 7 of segment I.

No. 7 corresponds to number 8 of segment I but is single rather than bifid.

Ventrad of segment II:

No. 1. A short hair similar in structure to number 7 of the dorsum of the prothorax.

Nos. 2 and 3. Slender and bifid. Number 2 is medium long. Number 3 is medium in length.

No. 4. Long, slender, and simple.

No. 5. Medium short, slender, bifid.

No. 6. Medium in length, slender, with 4 branchings.

Dorsum of segments III, IV, V, and VI:

No. 1. A single, short, fine hair.

No. 2. Long, slender, bifid.

No. 3. Medium in length, slender, and single except on segment V where it has 3 branchings.

No. 4. Long, slender, simple on segments III, IV, and V; bifid and somewhat shorter on segment VI.

No. 5. Very short and divided near the base on segments III and IV into 3 branches; on segments V and VI into 2 branches.

No. 6. Homologous with the corresponding hair on segment I.

No. 7 on segments III, IV, and V is homologous with the corresponding hair on segment II. This hair is not present on segment VI.

Ventrad of segments III, IV, and V:

No. 1. A slender, simple hair; short on segment III, medium in length on segment IV, and long on segment V.

No. 2. Bifid; short on segment III, medium in length on segments IV and V.

No. 3. Branched at the base into three long, slender hairs.

No. 4. Long, slender, and simple.

No. 5. Homologous to number 5 of segment II but simple rather than bifid on segment IV.

No. 6 on segments III and V is medium in length with 5 and 4 branchings respectively. Number 6 on segment IV is a short brush of from 6 to 8 hairs.

Ventrad of segment VI:

No. 1. Homologous with number 1 of segment II.

Nos. 2, 3 and 5. Long, slender, and simple.

No. 4. Bifid, medium in length.

No. 6. Simple and medium in length.

No. 7. Short and fine, divided at the base into 4 branches.

Dorsum of segment VII:

No. 1 is homologous to the corresponding hair on each of the preceding abdominal segments.

No. 2. Medium long with 3 branchings.

Nos. 3 and 5. Long, slender, single hairs.

No. 4. Homologous with number 5 on the preceding segment.

No. 6. A medium short brush, branched and rebranched near the base into from 15 to 20 hairs.

No. 7. A laterally inserted short hair of 4 branchings.

Ventrad of segment VII:

No. 1. A long slender hair with 3 branchings.
No. 2 corresponds with number 2 of segments I, IV, and V.
Nos. 3, 4, and 6 are long, slender, single hairs.
No. 5. Medium in length, divided at the base into 3 branches.

Laterad of segment VIII:

Located near the posterior margin of the eighth segment is the comb, a triangularly arranged group of scales. Each scale is somewhat rectangular in shape with one pointed end and a feathered tip. The comb consists of from 30 to 50 scales, the modal number being approximately 44.

Posterior to the comb and following the marginal line of the segment are five hairs of medium length.

Numbers 2 and 4 of this group are simple and unbranched. Number 3, the central hair, is profusely feathered and divided into 7 branches. Number 1 and number 5 each consist of 4 branches, the former having a few short barbs, the latter being feathered.

Anal segment:

The anal segment is completely encircled by a sclerotised, spicule-covered plate called the saddle. From this plate, near the posterior dorsal margin, extends a single medium long hair, the saddle hair.

The two conspicuous groups of hairs, the ventral and dorsal brushes, are located outside the saddle. The ventral brush consists of an irregular row of 5, 6, or 7 tufts, branched and rebranched into numberous hairs. The tufts vary in length, becoming progressively longer toward the posterior end of the segment.

The dorsal brush includes one very long, stout, single hair and another slightly shorter and more slender hair which usually has 2 branches. Both hairs arise from large papillae.

Siphon:

Ranging posteriorly from the base of the siphon is a longitudinal, ventro-laterally placed row of teeth collectively constituting the pecten. These are 13 in number, triangular in shape with a dentated edge, and are obliquely inserted. Also on the ventro-lateral surface of the siphon are four hair tufts of medium length. Number 1 has 4 branches, number 2 has 3 branches, numbers 3 and 4 each have 2 branches. Situated dorsally near the tip of the siphon is the very short apico-dorsal hair. At the apex of the siphon are five valves; a small medio-dorsal valve, paired dorsal valves, and a pair of larger ventral valves. On each ventral valve is one fine, unbranched hair located proximally, and at the distal end a short hooked spine. In some cases this valve also contains, near the distal end, a short, blunt, spine-like digit. There is a short, fine, unbranched hair on each dorsal valve. These five valves are hinged basally to the stirup-shaped piece within the siphon. From this piece a tapering spine-like projection extends posteriorly approximately twice the length of the valves.

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REARING OF THE DAMSEL FLY, ISCHNURA VERTICALIS SAY, IN THE LABORATORY

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The successful rearing of the naiads of Odonata has been accomplished by a number of workers; apparently the life cycle having been determined for about 18 species (Bick, 1941). Eight of these are members of the suborder Zygoptera or damsel flies.

Most workers in rearing naiads of Odonata have had relatively high death rates, particularly in the later instars. The writers were so successful in rearing the naiads of *Ischnura verticalis* throughout the greater portion of their development that it was thought worth while to describe their methods. These naiads were probably in the third or fourth instar when first observed, and were introduced when very small in a clump of grass that was collected from an overhanging bank of a pond. This species has been reared through its complete life cycle by Grieve (1937). Balfour-Browne (1909) has described the life history of *I. elegans* in England.

A general study of suitable methods for rearing aquatic insects was being made. The naiads of *Ischnura verticalis* were placed in a wooden aquarium (11″ x 30″ x 8″) and reared together. Pond water was used and maintained at a depth of two to four inches. The bottom was covered with sand and the top was open. A clump of grass was growing in one end. Fine bubbles of air were continuously liberated through a porous disk near the center of the aquarium. This kept the water saturated with oxygen and produced sluggish currents that prevented an accumulation of dust and microscopic growth on the surface. The room temperature was fairly constant and the water temperature remained near 16° C.

Apparently the naiads were hungry when first found, as attempts at cannibalism were observed, but they discontinued such efforts after hand feeding started. They scattered throughout the aquarium clinging to the wooden walls and usually kept well distributed. At times several of them would return to the clump of grass, but this did not affect their willingness to accept proffered food. It is not known whether the naiads succeeded in capturing any natural food in the aquarium, as little such food was observed.

We were rearing large numbers of house fly maggots at the time for other experiments and used these as food; small larvae or bits of larvae being offered at first, and larger maggots being offered as the naiads developed. At no time were the naiads, even when nearly mature, willing to accept maggots more than half grown, but they readily accepted fragments of the larger maggots, if these still wriggled. The maggots were held with a forceps and placed directly in front of the damsel flies. The naiads usually retreated if the struggling maggot touched them before they attempted to capture it. For a few minutes following this they were less likely to accept the proffered food. Immediately on grasping the maggot, the naiads moved backward and if the food was not quickly released from the forceps they would often abandon their prey. Maggots were not left in the aquarium if refused by the naiads. Food was offered every other day, after a few trials, since they seldom would accept food oftener. On the other hand, they seldom refused food on the second day. Similar techniques were used with immature stages of dragon flies, stone flies, caddice flies, and adult hydrophilids. The caddice flies were most difficult to feed, since they retreated into their cases unless approached cautiously or when touched.

The naiads crawled on the sides of the aquarium to emerge. Eight of the nine original naiads emerged between March 11 and May 15, one having died previously.

The low mortality and lack of cannibalism among our naiads suggests that the environment was very satisfactory. Maggots of *Musca domestica* L., while non-aquatic, were acceptable and satisfactory food. The temperature of the water remained near 16° and probably did not exceed 18° C. The water was saturated with oxygen at all times, and at a temperature of 16° would contain an abundant supply. Since many workers have reported high mortalities of naiads in the later stages, when reared in small containers at room temperature, it is probable that our success was closely related with temperature. Cannibalism, so frequent in small containers, was not a factor in our studies.

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SYNONYMS OF FORMICA DIFFICILIS EMERY (HYMENOPTERA: FORMICIDAE)[1]

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In 1939, I described as new the ant, *Formica habrogyna*. Some time after that a formicologist wrote me that he considers *habrogyna* to be a synonym of *difficilis* var. *consocians* Wheeler. Upon further study of long series of all castes of *habrogyna* and comparisons of them with topotypes of *consocians*, kindly sent to me by the American Museum of Natural History, I have arrived at an opinion that although *habrogyna* is undoubtedly identical to *consocians*, *consocians* is also well within the limits of specific variation of *difficilis*.

Although apparently there were, in the U. S. National Museum, numerous workers and a number of males and females of *difficilis* which had been collected at the type locality by Pergande and which might even represent a part of the type series, Wheeler established *consocians* after having compared his specimens with a single female from Virginia, two badly rubbed workers from New Jersey and a long series of workers and one deälated female collected in North Carolina. Since he based the variety primarily on a greater pilosity, it is easy to understand his overlooking such a variable character as pilosity in *difficilis*. Wheeler was apparently erroneously led to believe, therefore, that *consocians* is more hairy than *difficilis*.

Mr. W. F. Buren has informed me that he has compared metatopotypes of *habrogyna* with a worker and a female (possibly from the original type series) collected at Rosslyn, Virginia, by Pergande. He states that the specimens of *difficilis* are definitely more pilose and pubescent than are the metatopotypes of *habrogyna* with which he compared them.

Because of the great variability in pilosity of *difficilis*, and since there are no characters of sufficient significance for separating *consocians* and *habrogyna* from *difficilis*, I am, therefore, of the opinion that both *consocians* and *habrogyna* should be relegated to the synonymy which is as follows:

Formica difficilis Emery

F. pallidefulva Mayr (*nec* Latreille), 1866, Vehr. Zool. bot. ver. Wien, 16: 889.
F. rufa subsp. *difficilis* Emery, 1893, Zool. jahrb. Syst., 7: 651.
F. difficilis Wheeler, 1904, Bull. Amer. Mus. Nat. Hist., 20: 306, 348.
F. difficilis var. *consocians* Wheeler, 1904, Bull. Amer. Mus. Nat. Hist., 20: 371; *loc. cit.*, 1906, 22: 50; 1913, Bull. Mus. Comp. Zool., Harvard Univ., 53: 479–480.
F. habrogyna Cole, 1939, Amer. Midl. Nat., 22: 413–417; *loc. cit.*, 1940, 24: 76–77.

[1]Contribution No. 6, Department of Zoology and Entomology, University of Tennessee, Knoxville.

TWO NEW BUPRESTIDAE (COLEOPTERA)

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The Ohio State University

Chrysobothris ephedrae n. sp.

Male—Size and form of *C. deleta* Lec., robust, front bronze, clypeus, vertex, pronotum and scutellum metallic green, elytra cupreous, becoming more brilliant toward apices, legs and ventral surface bronze, pubescence moderate throughout.

Head convex; clypeus broadly emarginate; surface coarsely punctured, median line on occiput; antennae not extending to middle of pronotum when laid along side, serrate from the fourth joint.

Pronotum convex, slightly wider at base than apex, widest back of middle; sides broadly rounded from base to apex; disk convex; surface more coarsely punctured than head, small raised smooth area in front of scutellum and one each side in front of middle. Scutellum triangular, glabrous.

Elytra wider than pronotum; sides constricted back of humeri expanded back of middle, then narrowed to rounded apices, serrulate back of middle; disk convex, basal depression each side; surface densely punctured, punctures same size as on head.

Prosternum with short broad lobe. Abdomen confluently punctured, transverse smooth areas along anterior margins of third, fourth and fifth segments, irregular raised areas along sides of first four segments, last segment serrulate along sides, broadly emarginate at apex. Anterior femur with very small tooth, tibia arcuate, dilated at apex, lacking a tooth.

Length 7.5 mm.; width 2.8 mm.

Female—Last abdominal broadly rounded at apex.

Holotype male, allotype and paratypes from Las Cruces, N. M., May 12, 1941; paratypes from Texas: Pecos Co., May 8, 1941; Culberson Co., May 10, 1941, and Hudspeth Co., May 11, 1941. All material collected by D. J. and J. N. Knull from the foliage of Mormon tea (*Ephedra*) in which the species probably breeds. Type material in writer's collection.

This species should be placed next to *C. cupreohumeralis* Van D. according to Fisher's key.[1] The brilliant cupreous elytral apices will distinguish it from all related species.

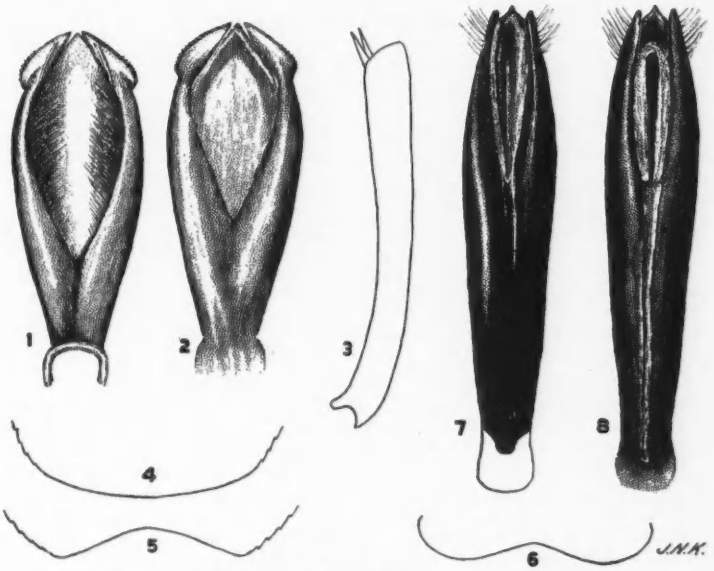
Agrilus diospyroides n. sp.

Male—Size, form and color of *A. otiosus* Say, elytra and ventral surface black, antennae, legs, head and pronotum aeneous varying to green, pubescence inconspicuous.

[1]W. S. Fisher, U. S. D. A. Misc. Pub. 470, pp. 1–274, 1942.

Head granulose becoming longitudinally rugose on occiput, slight indication of median depression; antennae not reaching to hind angles of pronotum when laid along side, serrate from the fourth joint.

Pronotum wider than long, widest in middle, as wide at base as in front; anterior margin strongly sinuate, median lobe broadly rounded; basal margin bisinuate, median lobe feebly produced; sides broadly rounded from base to apex, not sinuate; when viewed from the side, marginal and submarginal carinae joined at base; disk convex, two depressions along median line, lateral depressions well marked, prehumeral carinae well developed; surface feebly transversely rugose, granulose toward sides. Scutellum transversely carinate.



Chrysobothris ephedrae n. sp.

1. Dorsal view male genitalia. 2. Ventral view male genitalia. 3. Male anterior tibia. 4. Last visible abdominal sternite of female. 5. Last visible abdominal sternite of male. 6. Clypeus.

Agrilus diospyroides n. sp.

7. Dorsal view male genitalia. 8. Ventral view male genitalia.

Elytra at base wider than base of pronotum; sides parallel at base, constricted about middle, broadly rounded to rounded serrulate apices; disk flattened, basal depressions well marked; surface granulose.

Abdomen beneath lightly punctured, first two segments crenulate, flattened along median line, last abdominal rounded. Prosternal lobe broadly emarginate in front. All tibiae mucronate on inside at apices.

Tarsi on posterior pair of legs much shorter than tibiae, first joint as long as four following joints taken together, claws on all feet cleft, the outer tooth acute at apex, the inner one broader, turned inwards, the points touching.

Length 5.9 mm.; width 1.6 mm.

Described from four male specimens collected from the foliage of persimmon (*Diospyros virginiana* Linn.) in the Great Smoky Mountain National Park, Tenn., June 11, 1942, by D. J. and J. N. Knull, in the collection of the writer.

According to Fisher's key[2] this species would run to *A. frosti* Knull. It can be separated by the larger size, emarginate prosternal lobe and structure of the male genitalia.

[2]W. S. Fisher, U. S. National Mus. Bul. 145, pp. 1–347, 1928.

ATLAS OF THE SCALE INSECTS OF NORTH AMERICA, by G. F. FERRIS, 1942. Fourth Series, Nos. 385–444 (60 pls.), concluding the Family Diaspididae. 11 x 8.5 inches. Published by the STANFORD UNIVERSITY PRESS, Stanford University, Calif. Price, bound, $6.75; unbound, $5.75.

This volume of the notable publication by Dr. Ferris, issued in 1942, includes numbers 385 to 448 with table of contents and index and constitutes what may be the final volume of the series. As in earlier parts the method of arrangement, descriptions and plates is so as to facilitate ready comparison and the work must be considered as a very essential contribution to the studies of this important group of insects. In this family the characters of the female pygidia are of fundamental importance and are given specially complete representation in the illustrations and also detailed descriptions along with discussion of synonyms, hosts and distribution habit, recognition characters and notes dealing mainly with matters relating to earlier descriptions. Naturally as an "atlas" the illustrations have a most important function and it is easy to praise the admirable drawings as also the very successful reproduction of the plates. It is a far cry from the beautiful steel engraving which accompanied Signoret's "Essai Sur Cochenilles," 1870–'75, in which the pygidia were established as important characters and the Comstock articles in the early 80's, when these features were introduced to the American students, to the elaborate drawings by this author.

The general index covering series I to IV makes available reference to all the preceding parts. While it is easy to compliment the work without stint it seems that the work might have been more acceptable to workers in general if it could have been issued in book form, thus avoiding a repetition of title pages for every number, but the cost of publication must be taken into account. As it is, the author has evidently contributed financially very largely and his work must be considered in great degree a labor of love and not of personal profit.

In his epilogue referring to the probability that the work must be discontinued he states that if it is eventually continued the loose leaf form will be abandoned and a different procedure will be adopted. Stating that he stands ready to continue the work involved, he says, "If the world wants this Atlas of the Scale Insects of North America completed the world must find some way to pay for it."—HERBERT OSBORN.

THE LARVAE OF THE SUB-FAMILY ORPHILINAE AND THEIR BEARING ON THE SYSTEMATIC STATUS OF THE FAMILY DERMESTIDAE (COL.)

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In a recent paper I have discussed at some length the larval systematics of the sub-families of the *Dermestidae*. At the time I had not seen larvae of *Orphilinae*, nor had these been previously described, so I did not mention them.

Quite recently M. P. DE PEYERIMHOFF most kindly sent me four specimens of larvae, which he had raised and which proved to be *Orphilus niger* Rossi. The larvae are of more than ordinary interest as regards the exact position of the *Dermestidae* in the order *Coleoptera* and it appeared advisable to describe them.

The larvae studied were full grown and had been found in wood of *Quercus mirbechi*, in the forest of Mouzaia, (Algiers) Sept. 3, 1940 by M. P. DE PEYERIMHOFF. Eight specimens had been collected, of which four were sent to me.

DESCRIPTION OF THE LARVA

(Figs. 1–10)

Length, 6.5–7.25 mm.

Body cylindrical, rather elongate, dark brown on the sclerites, intersegmental membranes lighter. The whole sclerotized part of the body is covered with a close, regular, uniform, double pubescence; numerous short, thick curled setae and much longer finer setae, straight and rather sparse. All the setae are simple and there is no approximation to the complex setae which usually distinguish the *Dermestidae*.

Head short, broad, mutant; ocelli not visible; epicranial suture indistinct, sutures between labrum, clypeus and frons very visible. Labrum broad and short, its anterior margin completely covered with strong, short, truncate setae. Epipharynx with two oblique sclerified bands and between them with a transverse line of sensorii; two sensorii distally to this line. Antennae (fig. 1) very short, inserted inside the mandibles at the lateral angles of the clypeus, three-jointed, the distal joint with a stiff terminal bristle, the penultimate joint bearing a strong hyaline supplementary process.

Mandible (fig. 10) nearly straight on the caudal aspect, where it is distinctly setigerous at base; molar lobe very strongly tuberculate; apex bidentate; rostral aspect with a large, obtuse and feebly sclerotized retinaculum.

Maxillae (fig. 3) of the usual Dermestid type; palpus three-jointed, the last joint the longest, palpifer very distinct; galea without hooks, densely setiferous; lacinia with a long, slender, bidentate terminal hook.

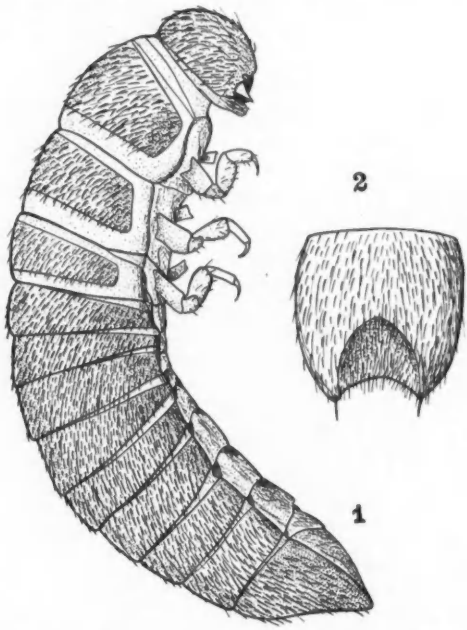
Labial palpus (fig. 6) two-jointed, the apical joint longer than the proximal joint which is strongly setiferous.

Hypopharyngeal bridge (fig. 5) very complex.

Thoracic segments posteriorly shorter; the tergum with a single sclerite; the sternum with no distinct sclerite.

Legs (fig. 8) short, rather stout and soft; coxae distant and exerted tarsal claw long, slender, strongly curved and with enlarged basis.

Abdomen nearly completely sclerified on the dorsal aspect.



Figs. 1 and 2. *Orphilus niger* Rossi. 1, Lateral view of body. 2, Dorsal aspect of the ninth abdominal segment.

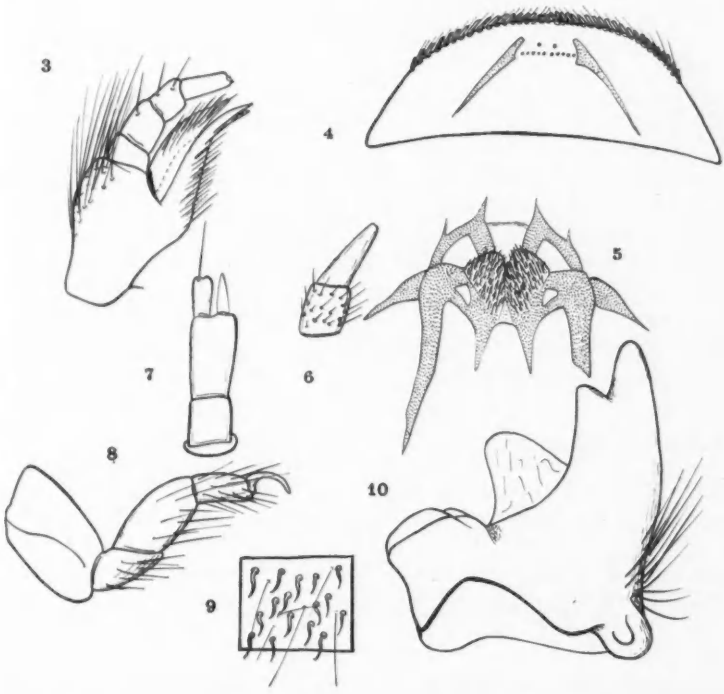
The pleural lobes not very distinct. Ninth segment rather long, its apical margin deeply sinuate, the apical angles well marked, each with a stiff and short bristle. Posterior third of the dorsal aspect of the segment excavated between the apical angles.

SYSTEMATIC POSITION OF THE LARVA OF ORPHILUS NIGER ROSSI

The sub-family *Orphilinae* groups about a dozen species known from Europe and the temperate parts of North and South

America. The Coleopterum Catalogus places this sub-family at the end of the *Dermestidae*, considering it, then, as being the most highly differentiated of all the family.

By its labrum, epipharynx, antennae, maxillae and labium this larva belongs decidedly to the *Dermestidae*, and by the



Figs. 3–10. *Orphilus niger* Rossi. 3, maxilla. 4, epipharynx. 5, hypopharyngeal bridge. 6, labial palpus. 7, antenna. 8, anterior leg. 9, detail of the pubescence of the prothoracic tergite. 10, mandible.

characters previously used for the systematic of the family, i. e., the entirely setiferous front margin of the labrum and the urogomphi, it should rank as a distinct sub-family.

But the general body shape and the quite simple pubescence are unique in the family and bring to mind certain sections of the *Cucujoidea*.

The most remarkable organs of this larva are its mandibles. In all the *Cleroidea* (of which the *Dermestidae* are a family) as far as they are known, the mandible is without molar lobe and without retinaculum. The mandible of *Orphilus* on the contrary has both a retinaculum and a molar lobe and bears evident affinities with the mandible of the primitive *Cucujoidea* such as *Nitidulidae* and *Languridae*. The peculiar body shape, with its excavated dorsal aspect of the ninth abdominal segment, though evidently it may be of an adaptative nature, is also much nearer to the body shape of the *Cucujoidea* than to that of the *Cleroidea*.

So it seems that the *Orphilinae* should be placed at the head of the *Dermestidae* and that they are a distinct link between the *Cucujoidea* and the *Cleroidea*. With the knowledge that most real Dermestid larvae are saprophagus it is not possible to consider the difference between the mandibles of *Orphilus* and of (f. i.) *Dermestes* as being of adaptative origin. Though the body shape may suggest a far-off analogy with the *Byrrhoidea* the anatomical data are completely against such a relationship. It appears also that the differences in the mandibles between *Cleroidea* and *Cucujoidea* are not of constant occurrence.

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THE SKELETO-MUSCULAR MECHANISMS OF THE HONEY BEE, by R. E. Snodgrass. 1942. Pages 1–120, 32 figs. 6½ x 9½ inches. Published as No. 2 of Volume 103, Smithsonian Miscellaneous Collections. Paper bound. Price from Smithsonian, 55 cents.

Snodgrass in America and Hermann Weber in Germany are responsible for the present method in the study of the insect skeleton, the method of considering the skeletal parts as one element in a unit system, the skeleto-muscular system. Any comparative anatomy must consider both skeleton and muscular system. Sutures and sclerotic unit areas had been the criteria in such comparative studies. Snodgrass and Weber put the comparative anatomy of the insect skeleton on a determination of parts by the insertions of the muscles associated with the various parts. The function identified the structure.

Snodgrass has worked on the anatomy of the honey bee for years. This volume summarizes his work in the skeleto-muscular system and as such is in more detail than his previous accounts. It is fully illustrated. The advertisement above lists 32 figures. Each of these "figures" is compound. The actual total is 239.—C. H. K.

DEVELOPMENT OF THE FEMALE REPRODUCTIVE SYSTEM IN RHAGOLETIS POMONELLA WALSH (DIPT.: TRYPETIDAE)[1]

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Although metamorphosis has been studied more intensively in the Diptera than in most orders of insects, comparatively little is known of the development of the secondary reproductive organs during the pupal period. A comprehensive study of metamorphosis of the sex ducts in both sexes of the blowfly, *Calliphora erythrocephala*, was published by Brüel (1) in 1897, who cited the works of Weismann (8), Künckel d'Herculais (3), Pratt (6) and Lowne (4) as comprising the literature on this subject at that time. Since then, Metcalfe (5) has described the formation of the female gonoducts in a cecidomyid, *Dasyneura leguminicola*, but there has been no work on the higher Diptera since that of Brüel, and none at all on the trypetids. The apple fruit fly, *Rhagoletis pomonella*, offers a typical example of the specialized female reproductive system found in this family. The writer has redescribed the adult structure (2) and this paper is presented as a continuation of that study.

THE INTRAPUPARIAL PHASES

The pupal period is much longer in *R. pomonella* than in the species studied by previous investigators, in which it lasts but a few days or weeks. The apple fruit fly overwinters as a pupa, remaining in this stage for nine to twelve months, with some individuals pupating for more than two years. The length of this period, coupled with wide individual variation in the developmental rate, even under similar conditions, necessitates the use of some index of development other than age. Fortunately, there are a number of fairly distinct morphological phases exhibited during the intrapuparial period and these, together with the approximate age of the individual, indicate the stage of metamorphosis to which the individual has attained. These phases may be sharply delimited by a molt or may pass more gradually into one another. Examination of a large number of pupae has disclosed few in intermediate stages, which seems to indicate that the transition from one phase to the next is rapid.

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 382, May 24, 1940.

The early intrapuparial phases have been described by Snodgrass (7). They comprise the *fourth larval instar*, the *cryptocephalic pupa* and the *phanerocephalic pupa*, the last showing two subphases—an early *microcephalic* condition of doubtful validity, and a later *macrocephalic* phase in which the pupa overwinters. Development recommences approximately one month before emergence of the adult, or about May 15 for the earliest individuals. At that time, the forming body wall and appendages of the adult become visible through the pupal integument and a phase, which the writer proposes to call the *teleomorphic*, is reached. This is the earliest stage in which the sex of the individual can be determined by casual observation, the external genitalia first appearing at this time. About two weeks later, pigmentation of the compound eyes indicates the attainment of the *chromoptic* phase and finally, about one week before emergence, the *chromogenic* phases occurs with the pigmentation of the body wall, wings and setae. The approximate ages at which the various intrapuparial phases occur are as follows:

1. Third instar larva leaves the fruit in which it has fed.
2. 12th hour—Puparium formed.
3. 24th hour—Molt to fourth instar larva.
4. 2d day—Molt to pupal stage (cryptocephalic phase).
5. 3d to 5th day—Phanerocephalic (macrocephalic) phase, the overwintering pupa.
6. 1 month before emergence—Teleomorphic phase.
7. 2 weeks before emergence—Chromoptic phase.
8. 1 week before emergence—Chromogenic phase.
9. Emergence of adult.

METAMORPHOSIS

Metamorphosis of the reproductive system involves the development of two distinct groups of organs, the gonads and the gonoducts. The former are entirely mesodermal in origin while the latter are primarily ectodermal but include some mesodermal structures. It will be more convenient to consider each group separately, while bearing in mind that their development is simultaneous. Arising from distinct histoblast groups in widely separated parts of the body, the gonads and gonoducts do not unite until metamorphosis is nearly complete. They may, therefore, be treated independently of one another without confusion.

DEVELOPMENT OF THE GONODUCT SYSTEM

This section deals with the formation of the greater part of the reproductive system—the oviducts, bursa copulatrix, spermathecae, accessory glands, vagina and ovipositor. Unlike the gonads, these organs are not found in the embryo, even as rudiments, but appear only after the beginning of larval life. Their metamorphosis is, in effect, a sort of delayed embryonic development.

First instar larva. There are no rudiments of the secondary sex organs present in the first larval instar, but a thickening of the epidermal cells around the anus, in the region where the histoblasts of the sex ducts later develop, probably indicates a specialization of these cells for the formation of the rudiments.

Second instar larva. The three histoblasts from which arise the gonoducts of both sexes are first found in the second instar larva. During the larval and earliest pupal stages there are no features which permit ready distinction between the male and female rudiments, so that the following descriptions apply equally well to either sex.

Immediately before the junction of the distal end of the rectum with the ventral body wall in the last larval segment is a small, transversely elongated and dorso-ventrally flattened histoblast (*M Hbl*) with a smaller, spheroidal histoblast (*L Hbl*) near either end. All three are attached to the inner surface of the body wall, the median histoblast at its middle and the lateral rudiments by one end. The latter are typical invaginated imaginal discs, but the median histoblast is a double structure, composed of two invaginated discs united at their points of attachment to the body wall. There are thus four discs giving rise to the sexual ducts. This corresponds to the number of rudiments found in *Volucella* by Künckel d'Herculais, but in that insect all four are separate. The condition in *Calliphora*, as reported by Brüel, is similar to that in *Rhagoletis*.

In section, the histoblasts are seen to be sac-like. The dorsal walls of the sacs are thickened to form the imaginal discs, and, in the lateral histoblasts, almost completely fill the peripodial cavities. The discs in the median histoblast are at its free ends, the middle portion being thinner walled. Peripodial stalks are lacking. There are no interconnections between the histoblasts, nor any with the gonad rudiments, which are a considerable distance away from them. The walls of the rudiments are formed by a single layer of elongated cells with conspicuous nuclei, and are covered by a thin, structureless membrane which is probably a basement membrane. The peripodial cavity is lined with an intima continuous with the cuticular layer of the body wall. This is quite conspicuous in the lateral rudiments but is much reduced in the median histoblast.

Third instar larva. The rudiments of the reproductive organs in the third instar larva are similar to those of the second instar but considerably larger (figs. 1, 2 and 9). The double median histoblast, in particular, is flattened medially, while those parts of the sac wall which form the imaginal discs are markedly thicker. From the free ends of the sac, slender cellular strands extend forward a short distance and then appear to unite with muscles of the body wall. Similar structures in *Calliphora* are said, by Brüel, to unite with the epithelium of tracheal branches, but such connections could not be seen in *Rhagoletis*.

Fourth instar larva, cryptocephalic and microcephalic pupae. After formation of the puparium, the rudiments of the secondary sex organs begin to enlarge and develop. The imaginal discs become more distinct as the thinner periblastic parts of the histoblast walls separate from them and bulge outward. An opening appears at the point of attachment to the body wall and enlarges until the imaginal discs come to lie on the surface of the body as the entire histoblast flattens out (figs. 3 to 8). The lateral discs are also everted in the same manner, and unite with the median discs so that, together, they form a thickened, roughly crescentic or semicircular papilla of elongated cells just before the

anus. This structure is visible externally as the *genital plate* (figs. 12 to 14). Three pairs of small invaginations appear in it, arranged one immediately behind the other along the median line. The most anterior of these are the rudiments of the lateral oviducts, the second pair forms two of the spermathecae, while the last pair gives rise to the accessory glands. The rudiments are composed of a single cell layer, or perhaps an aggregate of cells forming only one distinct layer. In sections, the most conspicuous cytological elements are the almost solid masses of nuclei. In addition, there is a small mass of cells capping the spermathecal and accessory gland rudiments and forming a second tissue layer above them. (fig. 10, *Mes*).

Early macrocephalic pupa. Early in this stage, the sex of the pupa becomes discernible. In the male, a single, large internal projection forms on the genital plate, instead of three pairs of smaller rudiments. Descriptions of succeeding stages apply only to the female.

EXPLANATION OF PLATE I

Fig. 1. Histoblasts of the gonoduct in a third instar larva, dorsal aspect of caudal end of body. × 30.
Fig. 2. Median histoblast of third instar larva, lateral aspect. × 100.
Figs. 3 to 8. Schematic stages in flattening out of the median histoblast during the fourth larval instar, lateral aspect. × 100.
Fig. 9. Longitudinal section through a lateral histoblast of the same third instar larva as in fig. 2. × 100.
Fig. 10. Sagittal section through the genital plate of an early macrocephalic pupa. × 100.
Fig. 11. Sagittal section through the genital plate of an overwintered macrocephalic pupa. × 100.
Fig. 12. Posterio-ventral aspect of the end of the abdomen of the same pupa as fig. 10, showing external appearance of the genital plate. × 50.
Fig. 13. External appearance of the genital plate of a macrocephalic pupa 12 days after formation of the puparium. × 50.
Fig. 14. External appearance of the genital plate of a macrocephalic pupa slightly more advanced than fig. 13. × 50.

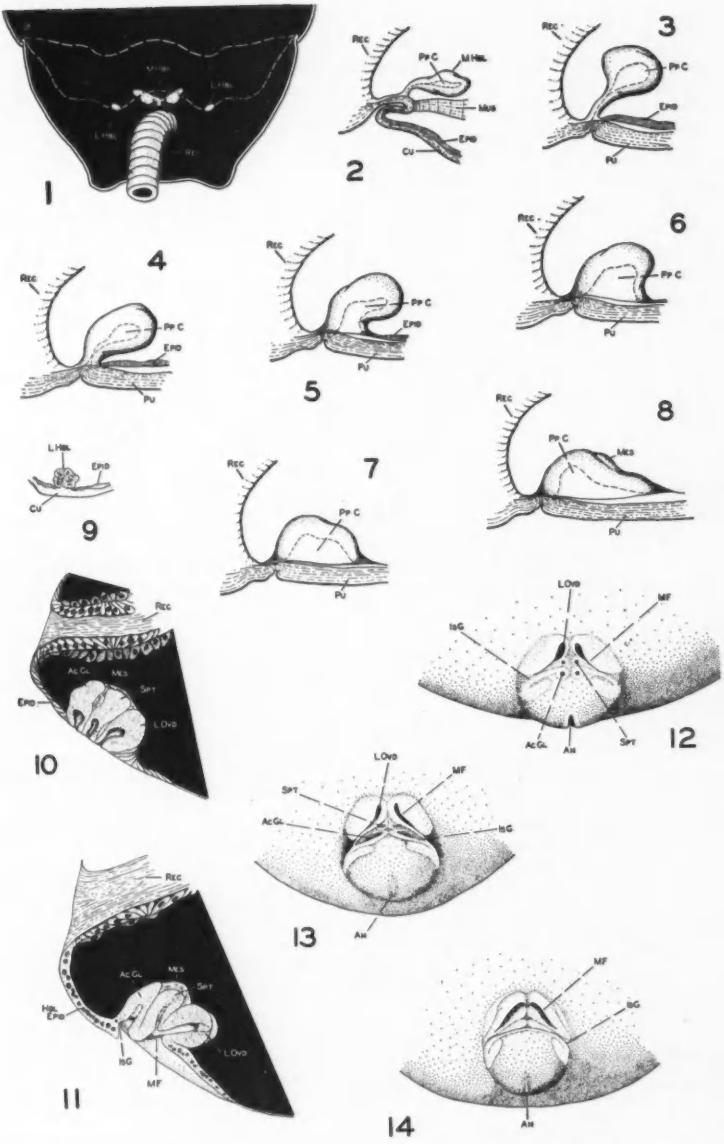
ABBREVIATIONS USED IN THE PLATES

Ac Gl—Accessory gland.
An—Anus.
Clo—Cloaca.
Cu—Cuticula.
Epid—Epidermis.
Ft Cls—Fat cells.
G Cls—Germ cells.
Hbl Epid—Epidermis derived from histoblast.
In Cls—Interstital cells derived from peripheral layer.
Is G—Intersegmental groove.
L Hbl—Lateral histoblast.
L Ovd—Lateral oviduct.
Mem—Membrane.
Mes—Mesoderm.
M F—Marginal fold.
M Hbl—Median histoblast.
M Ovd—Median oviduct.
Mus—Muscle.
Ov—Ovary.
Ovl—Ovariole.
Ovp—Ovipositor.
Ped—Pedicel.
Per Cls—Cells of peripheral layer.
Phr—Phragma.
Pp C—Peripodial cavity.
Prt Mem—Peritoneal membrane.
Pu—Puparium.
Rec—Rectum.
Sh—Sheath of ovipositor.
Sp—Spiracle.
Spt—Spermatheca.
T Fil—Terminal filament.
Tr—Trachea.
Vag—Vagina.
V Rcp—Ventral receptacle.

Roman numerals refer to abdominal segments

Rhagoletis pomonella Walsh
R. W. Dean

PLATE I



The paired invaginations increase in size, forming fingerlike projections on the inner surface of the genital plate (fig. 10). At the same time, a transverse fissure appears on its outer surface, immediately behind the accessory gland rudiments (figs. 12 to 15, *Is G*). This is the beginning of the intersegmental groove between the eighth and ninth abdominal segments. Similarly, marginal folds (*M F*) converge forward from the ends of the intersegmental groove to the openings of the lateral oviducts, and with it delimit a triangular area within which the three pairs of openings of the rudiments lie.

Middle macrocephalic pupa. The area covered by the genital plate increases, its cells replacing those of the pupal epidermis (fig. 11, *Hbl Epid*). The ends of the crescentic plate grow dorsad, surrounding the anus and uniting above it. At the same time, an imaginal disc in the anus itself begins to develop, and eventually unites with the genital plate, which now assumes an almost circular shape (fig. 15). The intersegmental groove also lengthens dorsally, its ends finally uniting above the anus and delimiting the ninth abdominal segment of the adult (fig. 17). Meanwhile, the marginal folds have met at the apex of the triangular area containing the paired openings of the internal rudiments, and this whole area begins to invaginate, being carried into the body by the anterior elongation of the rudimentary median duct (figs. 11 and 14 to 17).

Late macrocephalic pupa. The genital plate enlarges considerably and a second intersegmental groove, starting on the dorsal surface and lengthening ventrally, appears anterior to the now completed ninth segment (fig. 19). This groove delimits the disc-like eighth abdominal segment (fig. 20). The ninth segment has assumed a trilobate form, with the anus opening on the middle lobe. The lateral lobes enlarge and grow out beyond it, so that the anus no longer opens on the extreme posterior tip of the body (figs. 17 to 22). Meanwhile, the median duct has continued to elongate anteriorly within the abdomen, the three pairs of tubular

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EXPLANATION OF PLATE II

Fig. 15. External aspect of posterio-ventral surface of the abdomen of the same pupa as fig. 11. × 50.

Fig. 16. External aspect of the posterio-ventral surface of the abdomen of a late macrocephalic pupa. × 50.

Fig. 17. External aspect of the posterio-ventral surface of the abdomen of a late macrocephalic pupa. Marginal folds united with the intersegmental groove delimiting the ninth abdominal segment. × 50.

Fig. 18. External aspect of the posterio-ventral surface of the abdomen of a late macrocephalic pupa, slightly more advanced than fig. 17. × 50.

Fig. 19. External aspect of the posterio-ventral surface of the abdomen of a late macrocephalic pupa, showing partial development of the second intersegmental groove. × 50.

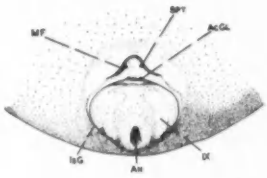
Fig. 20. External aspect of the posterio-ventral surface of the abdomen of a late macrocephalic pupa, showing completed second intersegmental groove and ring-like eighth abdominal segment. × 50.

Fig. 21. External aspect of the posterio-ventral surface of the abdomen of an early teleomorphic pupa, showing partly developed seventh abdominal segment. × 50.

Fig. 22. External aspect of the posterio-ventral surface of the abdomen of an early teleomorphic pupa, more advanced than fig. 21. × 50.

Rhagoletis pomonella Walsh
R. W. Dean

PLATE II



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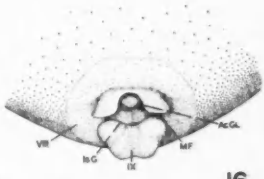

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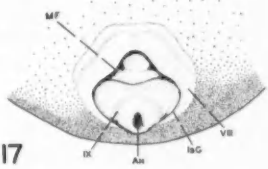

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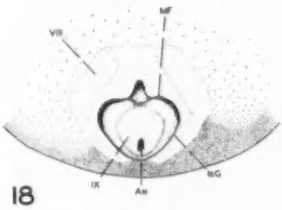

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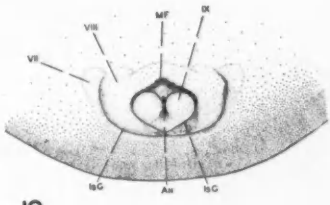

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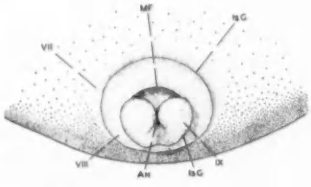

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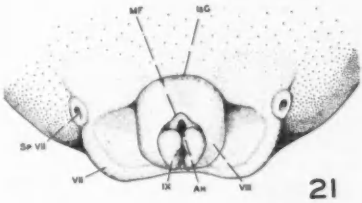

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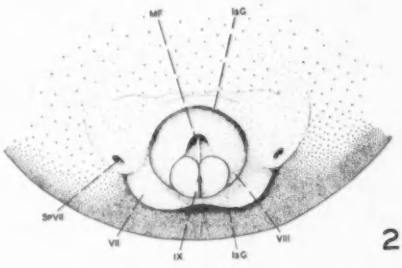

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rudiments remaining at its head and, themselves, enlarging (fig. 25). The lateral oviduct rudiments form a Y-shaped structure with the developing median duct. A third spermathecal rudiment appears between, and slightly before, the original pair. These, and the accessory gland rudiments, now exhibit a definite thin outer cellular layer derived from the cell mass (*Mes*) which previously capped them.

Early teleomorphic pupa. The seventh abdominal segment begins to form anterior to the eighth segment, and in much the same manner, the intersegmental groove starting on the dorsal surface and lengthening ventrally (figs. 21 and 22). Spiracular pits appear on this segment. The eighth segment becomes cylindrical as the intersegmental groove between it and the seventh segment deepens. The lateral lobes of the ninth segment cover the median lobe completely and become closely appressed behind it. The anal and sex-duct openings, at first comparatively distant, are now closer together (fig. 26). The median and lateral duct rudiments and the rudiments of the spermathecae and accessory glands are considerably longer.

Middle teleomorphic pupa. The seventh abdominal segment is completely delimited, with the phragma appearing as a transverse invagination near its anterio-ventral edge (fig. 23, *Phr*). Segment VIII lengthens anteriorly and the intersegmental groove between it and Segment IX becomes less distinct. The lateral lobes of the latter begin to fuse together and elongate, forming a single, tapering projection posterior to the anus, which is no longer visible externally. Within the body, the median and lateral ducts lengthen (fig. 27). A small depression in the floor of the median duct marks the beginning of the ventral receptacle (*V Rcp*). The ends of the spermathecal and accessory gland rudiments become slightly enlarged as division into gland body and duct starts. The outer cellular layer (*Mes*) which covers them extends over the lateral oviduct rudiments, and the beginning of a similar layer on the median duct is indicated by the appearance there of scattered peripheral cells. The lateral oviducts and the median oviduct proper, i. e., that part of the median duct anterior to the ventral receptacle, exhibit a slightly different cytological structure than the remainder of the median duct, the cytoplasm being clearer. In all organs, the intima is more sharply defined, while the epidermal cells of the ovipositor sheath show active secretion of cuticle.

EXPLANATION OF PLATE III

Fig. 23. External aspect of the posterio-ventral abdominal surface of a teleomorphic pupa, showing completed seventh abdominal segment. × 50.

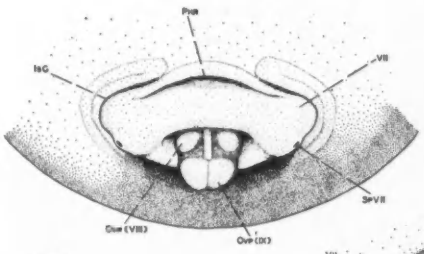
Fig. 24. External aspect of the posterio-ventral abdominal surface of a teleomorphic pupa, essentially imaginal in form. × 50.

Fig. 25. Abdomen of a macrocephalic pupa cut through the median plane, approximately the same stage of development as fig. 18. × 50.

Fig. 26. Abdomen of an early teleomorphic pupa cut through the median plane. Stage of development intermediate between that of figs. 20 and 21. × 50.

Fig. 27. Abdomen of the same middle teleomorphic pupa as fig. 23 cut through the median plane. × 50.

Fig. 28. Abdomen of a late teleomorphic pupa cut through the median plane. Stage of development approximately the same as fig. 24. × 50.



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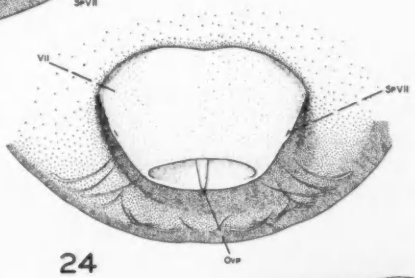

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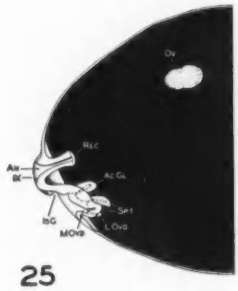

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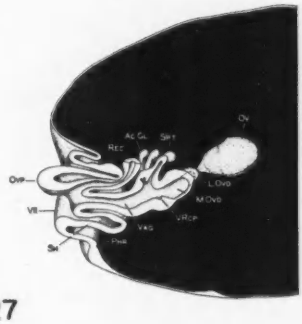

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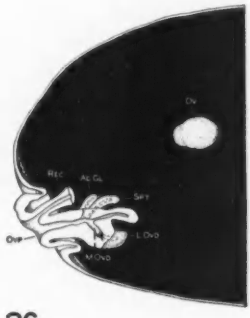

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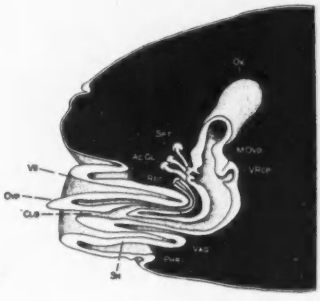

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The lengthening lateral oviducts form an initial connection with the gonads. At first this is ligamentous, but later a definite union is established, although the ends of the ducts remain closed. The anal opening and that of the median duct, which have approached each other gradually, now open into a shallow cloaca. Muscles of the body wall begin to form in segment VII.

Late teleomorphic pupa. The adult form of the structures is now distinct. The seventh segment has assumed a truncated-cone shape and only the tip of the ovipositor is visible externally (fig. 24). Its two component lobes are completely fused and are extended to form a slender, tapering point. Only the cloacal opening and the free ends of the ventral processes of the ovipositor remain to mark the junction of the eighth and ninth segments. Within the abdomen, the ovipositor has elongated anteriorly, with a consequent elongation of the cloaca, rectum and sex-duct. The ventral receptacle now forms a distinct invagination in the floor of the median duct, with the ducts of the spermathecae and accessory glands opening directly above it (fig. 28).

Near the end of this phase, the adult histological features appear. The change is very rapid and no intermediate stages were found. The sexual duct is divided into the lateral and median oviducts, bursa copulatrix and vagina. The thin outer cell layer gives rise to the muscle layers of the adult organs, the epithelial layer is reduced and, in most parts, the chitinous intima becomes thicker.

Chromoptic and chromogenic pupae. The only changes occurring before emergence of the adult are the establishment of connections between the ovarioles and the lumina of the lateral oviducts, and pigmentation of some of the organs. The former occurs in the chromoptic phase and, at the same time, the ovipositor assumes its typical amber color. Pigmentation of the body wall occurs in the chromogenic phase. By the time that phase is reached, the female reproductive system is, essentially, adult.

DEVELOPMENT OF THE GONAD

The gonad rudiments are a pair of small, ovoid bodies found in the tenth or eleventh body segments of the larva, where they lie, one on either side, imbedded in the lateral lobes of the dorsal fat body. They are not attached to the body wall, as is the case in many insects.

EXPLANATION OF PLATE IV

Fig. 29. Longitudinal section through a gonad rudiment in a first instar larva. × 500.

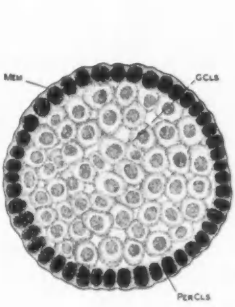
Fig. 30. Longitudinal section through a gonad rudiment in a fourth instar larva, showing a definite peripheral cell layer. × 500.

Fig. 31. Section through a gonad in a cryptocephalic pupa, showing the peripheral layer surrounding the central cell mass except where ovarioles are forming. × 500.

Fig. 32. Longitudinal section through a single ovariole in a teleomorphic pupa. × 500.

Fig. 33. Half of a cross-section through an ovary from an early teleomorphic pupa. × 500.

Fig. 34. Part of a cross-section through an ovary from a chromoptic pupa. × 500.



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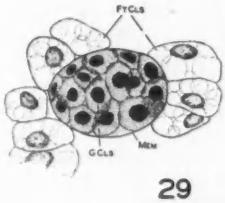

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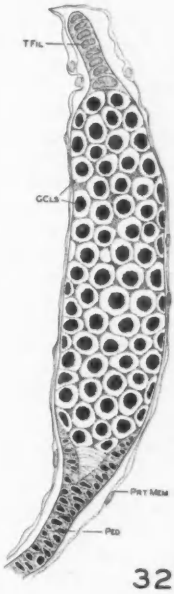

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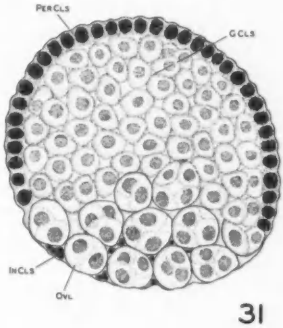

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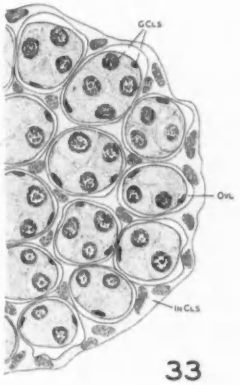

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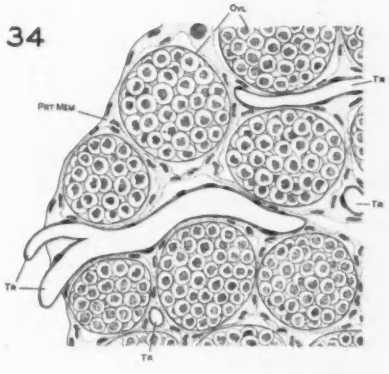

In the first instar larva, each rudiment consists of a mass of macronucleate cells (*G Cls*) surrounded by a thin membrane and is about 40 microns long by 25 microns wide (fig. 29). In the second larval instar they enlarge somewhat, being 45–50 microns long and 30–35 microns wide. Their structure is the same as in the first instar. In the third instar, the gonads may be found in either the ninth or tenth body segments, still imbedded in the fat body. The undifferentiated cell mass is beginning to separate into a peripheral layer of smaller cells and a central group of larger cells, and is still enclosed in a thin, membranous sac. The approximate dimensions are 85–90 microns in length by 40–50 microns in width.

The gonads in the fourth larval instar and early cryptocephalic phase are similar (fig. 30). They remain imbedded in the fat body but have become almost spherical, with distinct peripheral layers of cells with dark-staining nuclei (*Per Cls*). An external membranous covering is present as before. Size, 60–75 microns in diameter.

In the later cryptocephalic and microcephalic phases, transverse sections of the gonad appear round and measure approximately 80 microns in diameter (fig. 31). Actually, the gonad has begun to assume a bilobed shape, due to the development of the ovarioles. These structures make their first appearance at this time, forming by a sort of budding out from the inner end, i. e., the distal end, of the rudiment. As they enlarge, the gonad becomes bilobed, the developing ovarioles composing one lobe and the original cell mass forming the other. In transverse section, the ovarioles appear as thin, circular tubes containing a loose aggregation of macronucleate cells. Terminal filaments are present in the form of short columns of flattened, discoid cells.

The gonads do not develop at the same rate in all individuals, for in some pupae in an early macrocephalic phase there is yet no indication of ovariole formation and the peripheral layer is still distinct. As the ovarioles form, the peripheral layer disappears and its cells distribute themselves in the interstices between the ovarioles (*In Cls*). The gonad, which now measures 110–120 microns in length by 75–80 microns in width, is still covered by a structureless membrane.

As the ovarioles lengthen, the lobe composed of undifferentiated cells diminishes in size while the body of the gonad increases until, in the overwintered pupa, the rudiment measures 130 microns in length and 90 microns in width. In the late macrocephalic and early teleomorphic phases, the gonad is similar, but with more complete ovariole formation (fig. 33). The interspaces between the ovarioles are filled with small, elongated interstitial cells (*In Cls*) derived from the peripheral layer, while a single thin membrane surrounds the entire gonad.

In the teleomorphic phase, the ovarioles attain a form similar to that seen in the newly emerged adult (fig. 32). The cell mass contained in the ovariole tube now completely fills it, forming a solid cellular column 25 microns in diameter. The ovariole is divided into a distal terminal filament (*T Fil*), body, and basal stalk or pedicel (*Ped*). Definite cellular sheaths derived from the interstitial cells invest each ovariole (*Prt Mem*) and a similar cellular membrane covers the entire ovary. This last persists for a short time in the adult but disappears when the

TABLE I

Life Stage		Gonoduct Development		Gonad Development
		External	Internal	
First Instar Larva		None	Specialized hypodermal cells at site of future histoblasts.	Pair of ovoid cell-masses in posterior dorsal fat body.
Second Instar Larvae		None	Double median histoblast and two lateral rudiments formed.	Gonad slightly enlarged.
Third Instar Larva		None	Histoblasts enlarged, imaginal discs prominent.	Gonad enlarged, peripheral cell layer forming.
FORMATION OF PUPARIUM				
Fourth Instar Larva		None	Similar to above. Enlargement of histoblasts marked.	Gonad almost spherical, peripheral layer distinct.
PUPATION				
Crypto- and Microcephalic Pupae		Genital plate formed before anus.	Evagination and fusion of imaginal discs. Three pairs of invaginations formed.	Ovariole formation begins at anterior end of gonad.
Macrocephalic Pupa	Early	First intersegmental groove starts on ventral side. Two converging marginal folds formed.	Invaginations (=rudiments of lateral oviducts, spermathecae and accessory glands) enlarge.	Gonad enlarged, peripheral layer disappearing.
	Middle	Genital plate and anal histoblast unite. Intersegmental groove elongates.	Rudiment area invaginates, forming rudimentary median oviduct.	Gonad bilobed, larger lobe divided into ovarioles.
	Late	Segment IX delimited, second intersegmental groove starts on dorsal surface.	Median duct elongates, all rudiments larger. Third spermatheca appears.	Ovariole formation more complete.
Telemorphic Pupa	Early	Seg. VII begins to form. Seg. VIII complete. Seg. IX prolonged beyond anus.	All parts elongated. Gonopore and anus open externally in close proximity.	Three sections of ovariole differentiated, sheathed in cell-layer. Gonad larger.
	Middle	Seg. VII completed. Anus not visible externally. Seg. VIII and IX fusing to form ovipositor.	Ventral receptacle begins to form. Anus and gonopore open internally into a short cloaca.	First ligamentous connections between ovary and lateral oviduct.
	Late	Seg. IX elongated and pointed, fusion with Seg. VIII complete.	Ovipositor elongated, essentially adult in structure. Ventral receptacle enlarged.	Ovary and lateral oviduct united externally, no internal connection with lumen.
	Very Late	Essentially adult in form but unpigmented.	Histological differentiation of all structures.	Similar to above.
Chromoptic Pupa		Pigmentation of ovipositor.	Essentially adult in structure.	Ovaries open into lateral oviducts.
Chromogenic Pupa		Pigmentation of all parts.		
EMERGENCE OF ADULT				

ovarioles attain their full size. Strands of tissue grow out from these coverings toward the lateral oviduct rudiments, forming the first connections between the primary and secondary sex organs. The gonad proper then unites with the oviduct rudiment, the point of union being at the much reduced remnant of the original gonad cell mass. A connection between the ovary and the lumen of the oviduct is not formed until the chromoptic phase is reached.

TECHNIC

Material for sectioning was preserved in Kahle's fixative, dehydrated and cleared either in alcohol and xylol or alcohol and dioxane, and imbedded in paraffin. Serial sections, usually 10 microns thick, were cut through the entire larva or pupa. Delafield's hematoxylin was used for a nuclear stain and fast green FCF for a counterstain.

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STUDIES OF NORTH AMERICAN PLECOPTERA, with Special Reference to the Fauna of Illinois, by T. H. FRISON, published as Article 2, Vol. 22, Bull. ILLINOIS NATURAL HISTORY SURVEY, pages 231–355, figs. 1–126. 1942.

This volume is the eighth paper of considerable size published by Doctor Frison on the stone flies of the United States. It supplements his various other papers on the group but particularly cleans up the new species and obscure taxonomy of forms which are not mentioned or have only a limited treatment in "The Stoneflies or Plecoptera of Illinois."

The first eight pages are occupied by a discussion of the general problems in the taxonomy of this group. Frison divides the American forms into nine families. A revised list of Illinois species is given which now numbers forty-nine. The work in Illinois, which covers about fifteen years, has been thoroughgoing in the matter of rearing, of checking material carefully against existing types and in the matter of the hundreds of very carefully drawn illustrations. The present volume contains 436 individual figures. It is the type of taxonomy where funds and ability meet and the job is well done.—C. H. K.

THE EXTERNAL ANATOMY OF SANDALUS NIGER KNOCH (COLEOPTERA, RHIPICERIDAE)[1]

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The present study is a contribution to the knowledge of the external anatomy of coleopterous families. Although there have been many extensive phylogenetic studies of the Coleoptera such as Stickney (1923) on the head capsule, Williams (1938) on the mouthparts, Forbes (1922) and Graham (1922) on the wing venation, Sharp and Muir (1912) on the male genitalia, Tanner (1927) on the female genitalia and Boving and Craighead (1930) on larval characters in which parts of the various species of Rhipiceridae were described or figured there is no detailed description of a member of this family. It is intended that this study should parallel the work done by Blackburn (1936) on the Silphidae, Trimble (1935) on the Hydrophilidae, Hayes (1922) on the Scarabeidae, Rivnay (1928) on the Chrysomelidae, and Sweetman (1930) on the Coccinellidae.

PHYLOGENETIC CONSIDERATIONS

Horn (1881) was inclined to believe that the Rhipiceridae were related to the Dascyllidae and Forbes (1922) also placed the Rhipicerids in the Dascylloid group instead of the Elateroid group. Tanner (1927) from a study of the female genitalia and Williams (1938) from a study of the mouthparts both considered the Rhipiceridae related to the Elateridae and Buprestidae but in the Cantheroid series. Sharp and Muir (1912) also show a relationship of this family to the Elateridae and Buprestidae but place these three groups in the Byrrhoidea. Leng (1920) in his list of North American Coleoptera placed the Rhipiceridae in the Elateroidea and Stickney's (1923) phylogenetic studies of coleopterous head capsules indicated the same association.

From the present study it is evident that the Rhipiceridae are very primitive in some characters and highly specialized or

[1]This study was made under the supervision and direction of Dr. C. H. Kennedy, to whom the writer wishes to tender his sincere appreciation for the many helpful suggestions.

abberrant in others. Although specific characters such as genitalia are a useful tool to the taxonomist in separating species, the writer believes that the combined characteristics of the species should be considered in the broader problems of the relationships of genera and families.

SOURCE OF MATERIAL AND METHODS EMPLOYED

On October 5, 1939, a number of beetles of this species attracted the writer's attention by their appearance on several elms (*Ulmus americanus*) and upon shingle oak (*Quercus imbricarius*) in a suburb of northwest Columbus. Most of the females had settled upon the trunks of the trees from a height of two or three inches up to about nine feet, and were ovipositing beneath the bark scales. By means of their elongated ovipositor females were placing their eggs in cracks and crevices of the bark. This phenomenon was very interesting in that the ovipositor was nearly as long as the body of the female so that many eggs could be laid in various regions behind the female without the insect itself moving. One or two males were observed copulating but generally they were on the wing in the vicinity of trees or upon the trunks. All of these specimens were collected alive and the next day several more were obtained. The total collection consisted of about thirty females and six males. Dodge (1941) has mentioned this collection in his observations of *Sandalus*.

The insects were killed in a cyanide bottle and placed in a solution of 70 per cent ethyl alcohol. Dissections were made under a binocular microscope and the drawings made by the aid of the camera lucida. In some cases it was necessary to heat heavily pigmented and sclerotized portions of the insect in a ten per cent solution of potassium hydroxide. Where very delicate parts of the anatomy were concerned they were left in the potassium hydroxide solution for a week or more, no heat being applied.

GENERAL DESCRIPTION

Sandalus niger Knoch is an elongate, convex beetle, the female being more robust than the male. Males range from 17 to 18 millimeters in length and vary in color from black to light brown (fig. 1). In the light brown forms the antennae are orange and the thorax is darker than the elytra. Females range in length from 22 to 25 millimeters in length and are generally black or dark brown (fig. 2). The elytra are punctured and have a faint costa; they taper from base to apex in the

male and have their greatest width at the anterior end. In the female the elytra reach their greatest width at the posterior third of their length.

THE HEAD

The head capsule is roughly spherical with prominent antennal tubercles (fig. 4). The frontal suture is much reduced and is visible only in specimens treated with potassium hydroxide. The epicranial arms are well defined by the anterior border of the antennal tubercles. Fig. 3 displays a ventral view of the head showing the occipital foramen (Occ. For.) and the relation between the cervical sclerites (Cv. Scl.) and the head. The mouth-parts are directed ventrally and the head is partly withdrawn into the thorax. The compound eyes are large and visible both dorsally and ventrally.

The *antennae* are serrate in the female and flabellate in the male (figs. 8, 9). Eleven segments are present in both sexes, but in the antennae of the female the two distal segments are fused dorsally. The antennae are inserted into the prominent antennal tubercles directly above the base of the mandibles. The scape or first segment of the antennae is longest, while the pedicel or second segment is the shortest. In the female, segments three to nine have tooth-like projections anteriorly, while segments ten and eleven are more flattened. The segments distad of the second segment are termed the flagellum.

The *gula* forms the ventral exoskeleton of the head posteriorly (fig. 5, Gu.). It is bounded on either side by the gular suture (fig. 3, G. S.). The posterior margin of the gula defines the ventral aspect of the occipital foramen (Occ. For.). The mentum is separated by the dividing suture from the gula.

The *labium* is situated below and behind the maxillae (fig. 3, Lab.), and is attached to the head by the mentum and submentum. The mentum (fig. 3, 5) is roundly triangular and plate-like. It is attached proximally to the submentum which is much reduced. Williams (1938) terms the submentum the area between the mentum and the gula but no particular definition of parts is visible ventrally. The mentum and submentum are not considered by Crampton (1928) as parts of the labium proper. The eulabium or labium proper consists of the ligula, the palpiger and the palpus. The palpiger (fig. 5, Plg.) is attached proximally to the distal margin of the mentum and sparsely covered with fine setae. The ligula (fig. 5, Li.) is elongate, conical and covered with fine hairs. It lies anterior to the palpiger to which it is attached. The labial palpi are three-jointed, the first joint being very small; all are covered with hairs except the tip of the distal segment.

The maxillae are well developed and located between the mandibles and the mentum (figs. 3, 10, 11, Mx.). The basal piece or cardo (Cd) is small and sclerotized. The stipes (St) can be seen dorsally and is attached to the cardo at its proximal end. It is closely applied to the lacinia. The lacinia, (Lac) is a large and triangular plate covering the stipes and part of the palpifer ventrally. The galea, (Gal.) is cylindrical, hairy and joined to the interior, distal part of the lacinia. The palpifer, (fig. 10, Plf) is proximally joined to the stipes and bears the maxillary palpus at its anterior end. The maxillary palpi (fig. 11, Mx. Pp.) are

four-jointed, the first segment being very small; the remaining segments are large, cylindrical and densely clothed with hair. The tip of the distal segment is hairless and unpigmented; this is generally the area bearing sensory organs in insects.

The ***mandibles*** are large and heavily sclerotized (figs. 6, 7). A dorsal and ventral condyle, (D. c., V. C.) are present at the basal region of the mandibles. These articulate in cavities of the head capsule. MacGillivray (1923) gives the terms of preartis or dorsal condyle and postartis or ventral condyle. The distal and median portion of the inner edge of the mandible are provided with flat, tooth-like projections. The median tooth is very thin. The dorsal surface of the mandibles is fairly smooth but the ventral surface has a deep concave depression at the innermost median half.

The labrum is a small, bilobed structure (fig. 4, Lbr.) and is apparently fused to the head capsule since no suture separating the two can be found.

The ***endoskeleton*** of the head is much reduced as compared to the endoskeletal structures in other beetles, Stickney (1923). The tentorium consists of the anterior arms which have their external tentorial pits situated just anterior to the antennae and a pair of slender posterior arms which are parallel and dorsal to the gular suture (fig. 12, Ant. Arm., Post. Arm.).

THE CERVICAL SCLERITES

The paired sclerites of the cervix or neck are situated in the ventral membranous area connecting the head with the thorax, (figs. 13, 14). These articulate between the head and the sternum. Stickney (1923) terms the cephalic sclerite the ***cervepisternum*** and the thoracic sclerite the ***cervepimeron***. The cervepisternum is elongate and has tuberosities at each end. The cervepimeron is much smaller than the former and is elongate oval in form.

THE THORAX

The ***pronotum*** is conical, rounded and is finely punctured and hirsute; it is about as broad as long. The pronotum has a faint, median, longitudinal suture which is deepest anteriorly. A transverse, upturned ridge

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EXPLANATION OF PLATE I

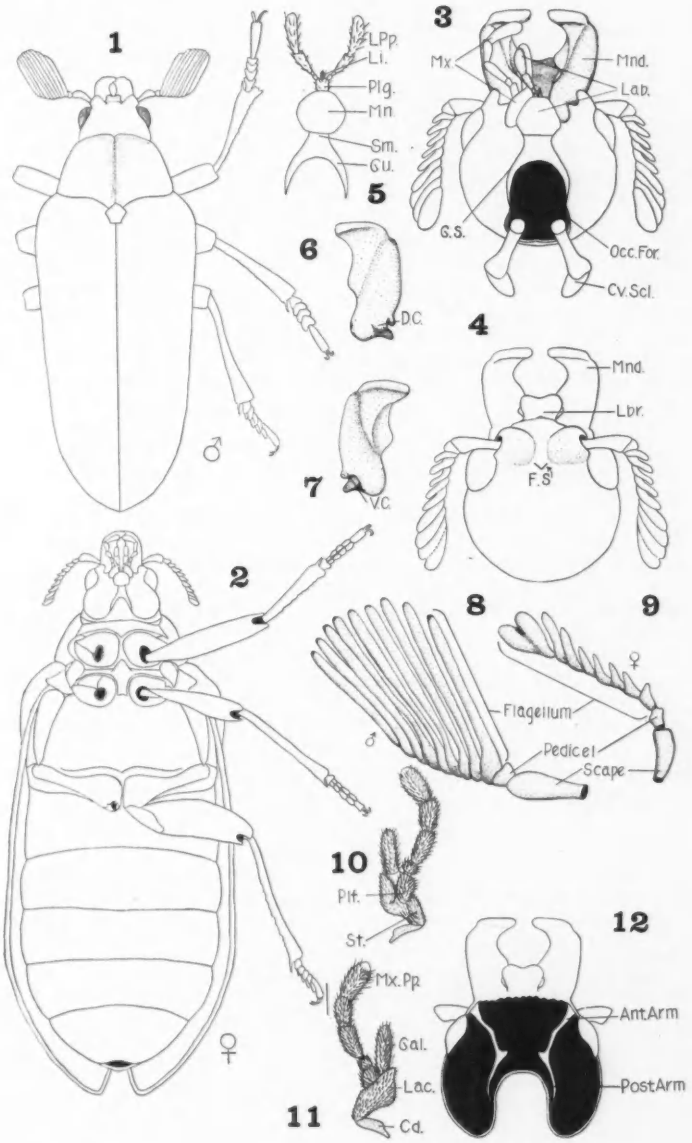
Sandalus niger

Figs. 1 and 8, male. Figs. 2–7, and 9–12, female. 1. Male. 2. Female. 3. Head and cervical sclerites. 4. Head, dorsal aspect. 5. Labium. 6. Mandible, right, dorsal surface. 7. Mandible, right, ventral surface. 8. Antenna, male. 9. Antenna, female. 10. Maxilla, left, ventral aspect. 11. Maxilla, left, dorsal aspect. 12. Tentorium, dorsal aspect.

Ant. Arm.—anterior arm of tentorium. Cd.—cardo of maxilla. Cv. Scl.—cervical sclerite. D. C.—dorsal condyle of mandible. F. S.—frontal suture. Gal.—galea of maxilla. G. S.—gular suture. Gu.—gula. Lab.—labium. Lac.—lacinia. Lbr.—labrum. Li.—ligula. L. Pp.—labial palpus. Mn.—mentum. Mnd.—mandible. Mx.—maxilla. Mx. Pp.—maxillary palpus. Occ. For.—occipital foramen. Plf.—palpifer. Plg.—palpiger. Post. Arm.—posterior arm of tentorium. Sm.—submentum. St.—stipes. V. C.—ventral condyle of mandible.

Sandalus niger
Roy Wilson Rings

PLATE I



on the anterior margin of the pronotum makes it possible for the head to be partly withdrawn into the thorax.

The ***prosternum*** is small and about four times as broad as long; the posterior median area of the prosternum bears a forked projection into which the anterior median projecting piece of the mesosternum articulates. Internally there are two pairs of furcae; the anterior pair is small and pointed while the posterior pair is larger and each branch is enlarged at its apex. These furcae are for the attachment of muscles (figs. 13, 14).

The ***mesotergum*** is small with only the scutellum heavily pigmented, (fig. 16). The scutellum (Sctl) is the only portion of the mesotergum visible when the elytra are folded in a natural position. The scutum, (Sct) (fig. 19) which makes up the greater part of the mesotergum is projected beneath the pronotum and is connected to the phragmata of the metathoracic praescutum, (fig. 16). The elytra articulate with the mesotergum by a membranous area containing the axillary sclerites (AxScl). There is also a median lateral projection termed the elytral articulation (fig. 16, Ely Art). The posterior lateral sides of the mesotergum are elongated to form the posterior notal wing process (fig. 19, PNWP), (Snodgrass, 1935). Internally there is a V-shaped ridge at the anterior portion and a faint V-shaped ridge at the connection of the scutum and the scutellum.

The ***mesopleuron*** is composed of two, principle plates (fig. 15). The episternum is elongate and bears upon the dorsal surface the wing processes of the elytra. An episternal suture separates the supraepisternum (S-Eps) from the infraepisternum (I-Eps). The episternum is attached posteriorly to the epimeron and at the dorsal portion of this junction there is a small groove in which the outer edges of the elytra fit when they are folded over the body. The epimeron is quadrangular and is rounded at all angles except where it joins the episternum. This junction is known as the pleural suture.

The ***mesosternum*** is twice as broad as long and is closely attached to the episternum. It is wider posteriorly than anteriorly and has a forward projecting piece on the median plane which articulates with the

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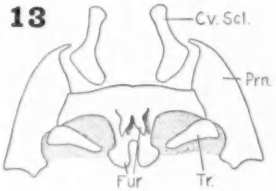
EXPLANATION OF PLATE II

Sandalus niger

13. Prosternum, dorsal internal view. 14. Prosternum, ventral external view. 15. Side view of thorax. 16. Mesotergum and metatergum, external dorsal view. 17. Metatergum, ventral internal view. 18. Mesosternum and metasternum, ventral external aspect. 19. Mesotergum, ventral internal view. 20. Mesosternum and metasternum, dorsal internal view.

Roman numerals refer to respective structures of the thorax. I.—prothoracic structures. II.—mesothoracic structures. III.—metathoracic structures. A. Ph.—anterior phragmata. Ax. Scl.—axillary sclerite. Cv. S.—convergent suture. Cv. Scl.—cervical sclerite. Cx.—coxa. Ely.—elytra. Ely. Art.—elytral articulation. Epm.—epimeron. Eps.—episternum. Fur.—furca. H. W.—hind wing. I.—Eps.—infraepisternum. M. D.—muscle disc. P. N. W. P.—postnotal wing process. Post. Sctl.—postscutellum. Praes.—praescutum. Prn.—pronotum. Sct.—scutum. Sctl.—scutellum. Sct-Sctl-S.—scutoscutellular suture. S-Eps.—supraepisternum. Sp.—spiracle. Spn.—spinasternum. St. I.—prosternum. St. II.—mesosternum. St. III.—metasternum. Ter.—tergite. Tr.—trochantin. Tr-I-S.—transverse intrascutal suture.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Cv. Scl.
Prn.
Fur
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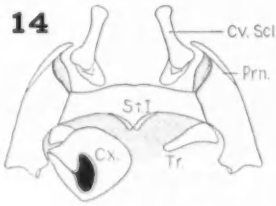
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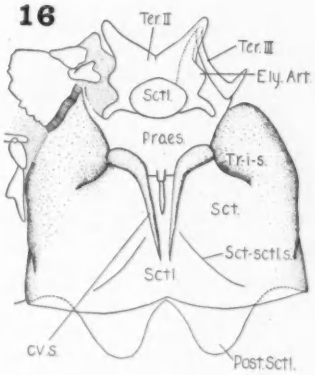
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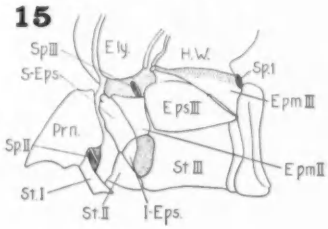
15
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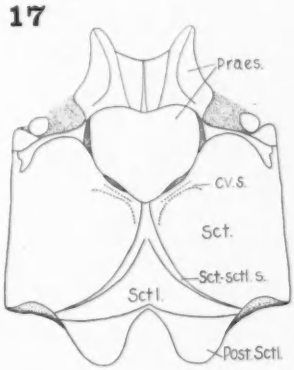
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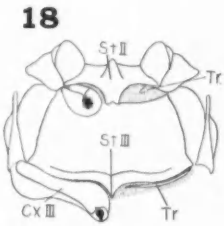
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St III
Cx III
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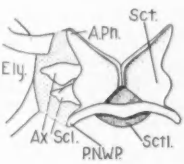
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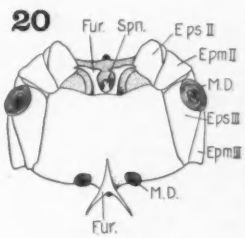
19


20
Fur.
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M.D.
Eps III
Epm III
M.D.
Fur.

complimentary bilobed piece of the posterior prosternum. The mesosternum also has a bilobed posterior projecting piece which probably represents the spinasternum. Snodgrass (1935) states that the spinasterna are intersternites of the thorax and that in some cases they are fused to the preceding sternite proper or eusternum. Each spinasternum bears a median apodemal process termed the spina (fig. 20, Spn). The posterior projecting piece of the prosternum no doubt also has such a relation to the prosternum. Internally besides the spina there is a larger bilobed furca (Fur).

The ***metatergum*** is the largest tergite, extending from beneath the pronotum posteriorly to and beneath the first abdominal segment. There are four principal divisions of the metatergum; first the perascutum which is attached anteriorly to the anterior phragmata of the mesotergum and lies beneath the scutum and scutellum of the mesothorax. Second the scutum, which is the largest sclerite of the tergum (figs. 16, 17). Anteriorly it borders the praescutum. The convergent sutures (Cv.S.) are arranged so as to form a pair of club-shaped areas in the medial tergal area. They arise anterolaterally from the scutum and gradually converge toward the median line of the tergum. A transverse intrascutal suture (Tr.I.S.) arises from the lateral margin of the convergent suture and extends posterolaterally. The scutoscutellular suture (Sct-Sctl-S) is V-shaped with its apex overlapping the apex of the convergent sutures although reversed. Internally the scutoscutellular suture forms a large V-shaped ridge, its apex directed anteriorly. Third the scutellum (Sctl.) is a comparatively small, triangular sclerite bounded anteriorly by the scutoscutellular suture and posteriorly by the suture separating it from the postscutellum. Fourth, the postscutellum, (Post.Sctl.) is the infolded, bilobed area which projects posteriorly beneath the primary abdominal tergites, MacGillivray (1923).

The ***metapleuron*** is large as compared to the mesopleuron and consists of two, large plates (fig. 15). The episternum (Eps. III) is roughly triangular and the dorsal projecting angle of the sclerite is narrowed into the parapterum. The epimeron (Epm. III) is lightly pigmented and somewhat membranous on the dorsal half but is hard and heavily pigmented otherwise. The forward projecting angle of the epimeron is narrowed and bears a knob-like wing process. Internally there is a large muscle disc (M.D.) attached to the epimeron.

The ***metasternum*** (figs. 18, 20, St. III) is much larger than the mesosternum with which it is closely united medially. It bears a median projecting knob which articulates with the spinasterna of the mesothorax. The close fit of this articulation serves to cover the membranous area between the mesothoracic coxae. There is a medial sternal suture having its origin at approximately the center of the sternum and extending posteriorly to the median end of the sternum. This suture evidently marks the inflection of the body wall to form the internal furcae. The metathoracic furca is a three-pointed structure, the anterior arm being the origin of the inflection and the two posterior arms extending lateroposteriorly for the attachment of muscles. A pair of muscle discs are situated on each side of the furca. A transverse suture is also present which curves parallel to the posterior margin of the metasternum.

THE THORACIC APPENDAGES

The *elytra* are punctate, heavily pigmented, and covered with a fine pubescence. The costa is faint. The elytra articulate with the lateral processes of the mesotergum, the elytral articulation and the wing process. They are joined to the tergum by a membranous area containing the axillary sclerites (Ax.Scl.).

The *hind wings* are membranous and of the usual coleopterous form. Forbes (1922) regards the Rhipicerid type of venation as being almost identical with the Dascyllid group. This author places these two types in the Dascylloidean type of wing structure, which is characterized mainly by the lack of characters of the other groups, thus resembling the more primitive types of Macrodactylia and Clavicornia. The costa is short with very little membrane anterior to it. The subcosta is approximately two-thirds the length of the wing. The radius is reduced and broken up into darker areas. The stem of the radial sector (RS) is combined with the radial cross-veins (r). The radio-medial crossveins connect the medius (M) with the stem of the radial sector. The medius is clearly defined and is anteriorly bent back to form a hook. The first medial branch is separated from its origin but distinct and the second and third medial branches are wanting. The fourth medial branch is fused with the cubitus to form the medio-cubital branch (M_4+Cu). The cubito-anal crossvein (cu-a) connects the medial with the second anal vein and its branches, ($2A_1$, $2A_2$). The first anal vein is isolated (1A). The third anal vein is forked and is connected to the second anal vein by the characteristic wedge cell (w). A fourth anal vein is also present.

The *thoracic spiracles* are situated in membranous areas of the meso- and metathoracic segments (fig. 15, Sp. II, Sp. III) although they appear to be in the pro- and mesothorax respectively. The first thoracic spiracle is located just posterior to the union of the pronotum and prosternum. The second is located dorsally of the mesothoracic epimeron.

The *legs* are similar in structure. The prothoracic legs are the smallest and the metathoracic legs the largest. The prothoracic and mesothoracic trochantins are small and crescent shaped (figs. 13, 18 Tr.). The hind trochantin is very elongated. The first and second coxae are globular, while the hind coxa is transversely elongated with a distinct ridge. The hind coxae cover the first two abdominal segments. The prothoracic and mesothoracic coxae are separated by the sternites and the spinasterna. The trochanter is small but distinct, (Trc.). The femora (Fem.) are smooth and are supplied with ventral grooves into which the proximal region of the tibia fit when the legs are folded (fig. 2). The tibia, (Tb.) is smooth on its inner surface but roughened and hairy on the outer side. The tibia bears two, short, curved spines at the inner apex, (Tb.Sp.). The tarsi are all five-jointed. The first four segments bear the tarsal pulvilli or hairy pads (fig. 25). The distal tarsal segment is the largest and bears two sharply hooked claws and between these a small arolium. The arolium consists of two parts; the basal unguitractor which is oval and deeply cleft at its distal end; the empodium or distal segment, which is club-shaped and bears short setae at its base, but longer setae on the terminal portion. Hayes and Kearn (1934) have figured both the arolium and the tarsus of *Sandalus niger*.

THE ABDOMEN

The tergites of the abdomen are thin, overlapping and light brown in color (fig. 28). The first segment is membranous, with a V-shaped median line, the apex of which is directed posteriorly. The second segment is also membranous though more pigmented than the first. The lateral margins of the first and second segments extend ventrally and anteriorly and the first includes the first large abdominal spiracle (fig. 15, Sp. 1). The third to seventh tergites are visible dorsally with the wings and elytra removed. These segments are more heavily pigmented than the first two tergites. The eighth segment is partly retracted into the seventh and is eversible. It is comparatively small and pigmented and hairy at its anterior half.

The segments labeled ninth (IX) appear to be clearly defined in both sexes but it can not be certain that this terminology is absolutely correct until a study of the post embryonic development has been made. The ninth and tenth segments envelop the genitalia of the male and form most of the external portion of the female ovipositor.

The sternites are more heavily sclerotized and pigmented than the tergites. They are the same color as the ground color of the beetle. The first abdominal sternite is entirely membranous and is covered by the metathoracic coxae. The second segment is membranous except for the posterior lateral margins where it is sclerotized. The third to seventh abdominal sternites are finely punctate. They overlap and are covered with fine hair. In the female the eighth sternite is normally retracted within the seventh and in the male the tip of the eighth segment is exposed in a natural position. The eighth, ninth and tenth abdominal sternites and their appendages constitute the genitalia of the female.

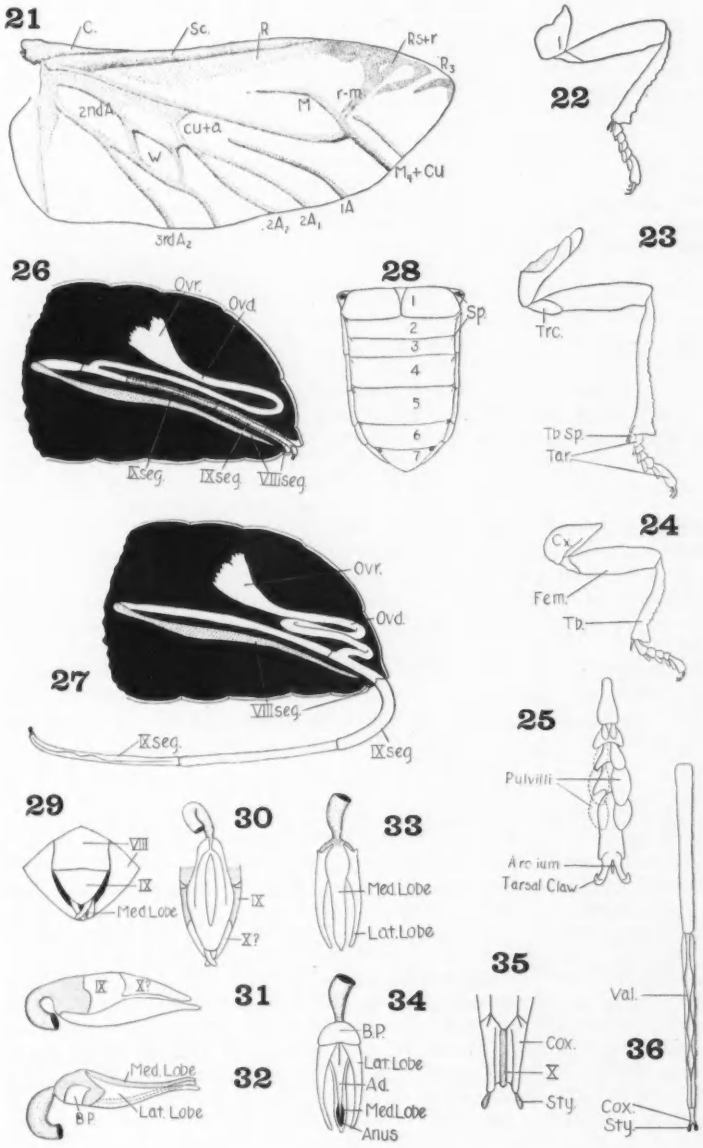
The ***abdominal spiracles*** are eight in number. The first spiracle is largest and best developed (fig. 28, Sp.). It is situated in the membranous first tergite of the abdomen close to the thorax. The second-third, fourth, fifth and sixth spiracles are well defined in small semi-sclerotized areas at the anterolateral angle of each abdominal tergite.

EXPLANATION OF PLATE III

Sandalus niger

Arabic numerals refer to the first seven segments of the abdomen. Roman numerals VIII, IX, X refer to the terminal abdominal segments. 21. Hind wing. 22. Mesothoracic leg. 23. Metathoracic leg. 24. Prothoracic leg. 25. Tarsus. 26. Female abdomen, side view showing ovipositor retracted. 27. Female abdomen, lateral view showing ovipositor extended. 28. Female abdomen, dorsal view. 29. Tip of male abdomen, ventral view; seventh sternite removed. 30. Ninth and tenth male abdominal segments, dorsal view. 31. Ninth and tenth male abdominal segments, lateral view. 32. Phallic organs, lateral aspect. 33. Phallic organs, dorsal aspect. 34. Phallic organs, ventral aspect. 35. Tip of ovipositor, ventral view. 36. Ovipositor, ventral external aspect.

A.—anal vein. Ad.—aedeagus. B. P.—basal piece. C.—costal vein. Cox.—coxite. Cu.—cubital vein. cu.—cubital crossvein. Cx.—coxa. Fem.—femur. M.—medial vein. m.—medial crossvein. Ovd.—oviduct. Ovr.—ovariole. R.—radial vein. r.—radial crossvein. Rs.—radial sector. Sc.—subcostal vein. Sp.—spiracle. Sty.—stylus. Tar.—tarsus. Tb.—tibia. Tb. Sp.—tibial spur. Trc.—trochanter. Val.—valvifer. w.—wedge cell.


21
C.
Sc.
R
RS+r
R3
r-m
M
2ndA
cu+a
W
M4+Cu
3rdA2
2A2
2A1
1A
22
1
23
Trc.
Td Sp.
Tar.
24
Cx.
Fem.
Td.
25
Pulvilli
Arc ium
Tarsal Claw
26
Ovr.
Ovd.
IX seg.
IX seg.
VIII seg.
27
Ovr.
Ovd.
VIII seg.
IX seg.
IX seg.
28
1
2
3
4
5
6
7
Sp.
29
VIII
IX
Med Lobe
30
IX
X?
31
IX
X?
32
Med. Lobe
B.P.
Lat. Lobe
33
Med Lobe
Lat. Lobe
34
B.P.
Lat. Lobe
Ad.
Med Lobe
Anus
35
Cox.
X
Sty.
36
Val.
Cox.
Sty.

These spiracles are hidden in the folds of the segments where the sternites and tergites converge. The seventh spiracle appears to be situated in the anterolateral margin of the tergite itself. The area which surrounds the spiracle is more heavily pigmented than in preceding segments. The eighth spiracle is situated on the ventral edge of the eighth tergite.

THE MALE GENITALIA

The sclerotized portion of the male genitalia consist of four structures, only one of which, the paired lateral lobes, is double. These sclerites are completely enveloped by the ninth segment (fig. 31, IX). The basal piece (figs. 32, 34, B.P.) forms the proximal portion of the genitalia. Dorsally the median lobe (fig. 33) is elongate, enlarged at its base and narrowed at the terminal end. There is a small knob at the tip of the median lobe. This structure is membranous basally but the remainder is pigmented and sclerotized. The median lobe serves as a protection to the aedeagus which it envelops laterally and dorsally. When viewed ventrally the interior of the median lobe is supplied with membranous tissues which appear to surround the anus (fig. 34).

The lateral lobes are comparatively large, roundly pointed at their apex and widening at the base where they converge ventrally. According to Sharp and Muir (1912) the term "lateral lobes" is synonymous with the parameres or "claspers" of other authors. The long slender piece ventral to the median lobe seems to be a specialized structure which is not present in the Rhipicerid *Callirhipes* of Sharp and Muir. This structure is thought to be the aedeagus which Snodgrass (1935) describes as typically a sclerotic tube. The aedeagus is very narrow and tubular distally but wider at the base. It bears a small gonophore or median orifice at the tip. The membranous tube attached to the proximal end of the median lobe is apparently the internal sac as described by Sharp and Muir (1912) in *Callirhipes*. The duct is greatly enlarged just above the aedeagus.

THE FEMALE GENITALIA

The genitalia of the female *Sandalus niger* are very complex internally and the associations of the various structures are not clear in preserved material. It is fairly evident that the various structures which constitute the ovipositor are segments or appendages of the eighth, ninth and tenth abdominal segments. The long slender sclerotized rod to which the retractor muscles of the ovipositor are attached appears to be an apodeme of the eighth sternite (figs. 26, 27). Tanner (1927) mentions several species of Coleoptera which have one or more apodemal structures extending anterior to the eighth sternite. The ninth segment is membranous though it is lightly pigmented. It is turned completely inside out when the ovipositor is retracted within the body (fig. 26). The two figures 26 and 27 are somewhat diagramatic but the writer has endeavored to show the relation of parts when the ovipositor is extended and when it is contracted. The ninth valvae consist of the valvifers, (Val.), the coxites (Cox.), and the styli (Sty.) (fig. 37).

The sclerotized remnant of the tenth sternite is found between the coxites on their ventral surface.

The coxite is setiferous and bears a small stylus. Tanner (1927) states that the valvifer is present only as a long, slender baculum. The baculum is, according to his terminology, the rod-like structure supporting the valvifers, coxites or styli.

The internal organs of reproduction have not been worked out but it is hoped that the writer may be able to do this in the future since the connections of these organs to the external parts might serve as very important sources of information as to the location of specific features. The path of the eggs was followed and it was found that the eggs pass through the ovariole, oviduct and into a lightly pigmented tube which leads into the ninth tubular segment. This tube may be a part of the ninth segment; the eggs pass out through an opening between the styli. The ovarioles are not closed but seem to be disintegrated in their anterior portions so that the eggs fill the entire abdominal cavity and also in part the thoracic cavity. It is apparent that most of the internal organs and tissues of the abdomen more or less disintegrated during the oviposition period. It is thought that all of the energy and assimilative materials possible are given over to the mass production of eggs. The enormous number of 16,864 eggs were counted in a large female.

SUMMARY

This study of *Sandalus niger* Knoch, Family Rhipiceridae, is a contribution to the knowledge of the external morphology of coleopterous families. It is intended that this work should parallel anatomical studies by others on various families of the Coleoptera. Although there are many extensive phylogenetic studies of the Coleoptera on the head capsule, mouth parts,wing venation, larval characters and both male and female genitalia in which such parts of the various species of Rhipicerids (*Sandalus* and *Callirhipes*) were described or figured there is no detailed description of a member of this family.

The Rhipiceridae are apparently very primitive in some characters but rather highly specialized in others, hence the sum total of these characteristics must be considered in the phylogeny of the family.

The ovipositor of the female seems to be very unusual and when extended nearly equals the body in length. A superficial study of the internal organs of reproduction of the female indicates that most of the tissues of the abdomen transform their accumulated energy over to the mass production of eggs. 16,864 eggs were counted in a single, large female.

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APPLIED ENTOMOLOGY. An Introductory Textbook of Insects in their Relations to Man. By H. T. FERNALD AND HAROLD H. SHEPARD. Pages x + 400. 283 figures; fourth edition, 1942. 6 x 9 inches. Published by MCGRAW-HILL BOOK COMPANY, INC., New York. Price, $3.50.

While nearly a third of this book has been rewritten in order to include new information on insect control, there is no fundamental change from previous editions in the style or scope of the book. Chapters I–IV deal with the place of insects in the animal kingdom, and with the structure and development of insects; Chapters V–IX deal with the economic importance of insects, and with insecticides and other means of insect control; Chapter X deals with classification; Chapters XI–XXXIII deal with the various insect orders; and Chapter XXXIV deals with animals other than insects.

Chapters V–IX have been completely rewritten and brought up to date, and include new insecticides that have come into general use; methods and materials of recent development that have not yet had widespread use are treated but slightly or not at all.

The fact that this book is in its fourth edition indicates its popularity and usefulness in beginning courses in economic entomology. There are two rather important phases of the subject, however, which this book either omits or gives but slight treatment. There is no general discussion of insect ecology—to give the student a background for thinking of control in terms of ecology—and there is only a single page on biological control, a subject which would seem to deserve more consideration in a text of this sort.

This book is one of the "McGraw-Hill Publications in the Agricultural Sciences," and has the excellent binding, paper, and workmanship of these publications.—D. J. BORROR.

THE MOUTHPARTS OF BLACKFLIES WITH SPECIAL REFERENCE TO EUSIMULIUM LASCIVUM TWINN[1]

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The work herein described is a special study of a local species, *Eusimulium lascivum* Twinn. Though this species occurs in considerable numbers at the outlet of Cayuta Lake, N. Y., it has never been taken, to the author's knowledge, in the act of taking blood. Whether it is a bloodsucker is doubtful for, despite its abundance, it did not attack while the author was collecting his specimens.

THE STRUCTURE OF THE HEAD AND MOUTHPARTS OF THE FEMALE

THE HEAD CAPSULE

The head capsule of *Eusimulium lascivum* Twinn (female) is roughly spherical in shape. It is flattened antero-posteriorly and truncate at its junction with the mouthparts which are suspended from the ventral surface.

The cephalic aspect of the head is made up of the fronto-clypeus, the vertex, and the eyes. The convex fronto-clypeus extends up from the mouthparts to meet the vertex, which extends down from the top of the head. Between the two are the antennal sockets.

The lateral areas of the head are almost entirely taken up by the eyes. The genae are only slightly lateral, each being a very narrow sclerite between the eye and the mouthparts. The postgenae and vertex extend somewhat to the lateral surface.

The posterior surface of the head is made up of the occiput, postgenae, the sclerites of the fused cardo and stipes, and a narrow membranous area between them. All of these surround the foramen magnum. The occiput extends down from the vertex to about the level of the occipital condyles. The areas on either side of the foramen magnum are occupied by the postgenae which extend from the lower edges of the occiput to the upper ends of the mouthparts. They also extend below the foramen magnum covering all of this area with the exception of that taken up by the sclerites of the cardo and stipes and the membranous area between them. The occiput, genae, vertex, and postgenae are not separated by sutures in this fly. The limits of these sclerites, as described above, are as defined by Jobling (1928) for *Culicoides pulicaris*.

[1]Contribution from the Department of Entomology, Cornell University, Ithaca, N. Y.

THE MOUTHPARTS, RELATIVE POSITION

In blackflies the mouthparts are suspended in a continuous membrane from the lower surface of the head capsule. This membrane, in addition to binding the mouthparts to the head capsule, joins them with one another. They articulate either with sclerotized extensions of the head capsule or act freely in the membrane.

The labrum-epipharynx is in front of all the rest of the mouthparts. Behind it are the mandibles. Their proximal ends are lateral to and behind the lateral limits of the labrum-epipharynx. Their distal ends lie one over the other in the midline. Next come the maxillae. Each consists of a palpus, a galea, and a fused cardo and stipes. The sclerite of the cardo and stipes is attached to the posterior wall of the head. The hypopharynx lies in the midline suspended from the posterior wall of the pharyngeal pump, behind the crossed ends of the mandibles, mesad to the galeae, and immediately anterior to the labium. The labium, which is composed of two three-segmented lobes partially fused in the midline, contains the other mouth-parts in its troughlike anterior face.

DETAILED DESCRIPTION OF THE MOUTHPARTS

The labrum-epipharynx. The labrum-epipharynx is essentially a three-sided pyramid with its base attached to the head, (Plate I, D, E; II, C; LBR.-EP.). The two lateral walls attach to the membrane suspended from the fronto-clypeus. The posterior wall is continuous with the anterior wall of the pharyngeal pump, (Plate II, C; LBR.-EP.). The labrum-epipharynx is largely membranous, with sclerotized areas along the corners formed by the three walls and along the midline of the posterior wall, (Plate I, D, E; II, C; LBR.-EP.). The sclerotization along the anterior corner is Y shaped. The arms of the Y form the bases of the lateral walls. They meet extensions from the sclerotizations at the lateral corners, whose other arms continue posteriorly to the lower anterior corners of the pharyngeal pump, (Plate II, C). These two points of contact form the fulcra for the levation and depression of the labrum-epipharynx. The four longitudinal sclerotizations meet at the apex to form a strongly sclerotized point.

Musculature. Two sets of muscles are inserted on the sclerotization of the posterior wall of the labrum-epipharynx. The proximal set takes its origin on the fronto-clypeus just above its junction with the labrum-epipharynx. The distal set arises at the junction of the arms of the Y-shaped anterior sclerotization (Plate II, C; COMP. LBR.-EP.). Inserted on the same region is a group of muscles whose origin is on the midline of the fronto-clypeus between the origins of the dilators of the pharyngeal pump (Plate II, C; LEV. LBR.-EP.).

The first two groups of muscles are evidently compressors of the labrum-epipharynx. Their contraction would increase the size of the food channel formed by the mouthparts and perhaps, in this way, be the first step in the pumping process. The third set of muscles acts as the levator of the labrum-epipharynx which swings on its fulcra as described above.

A fourth muscle, associated with the muscles of the labrum-epipharynx, takes its origin on the vertex. Its insertion is on the fronto-

clypeus at its junction with the vertex, (Plate II, C; TENS. FR.-CL.). This muscle is probably a tensor muscle to prevent the fronto-clypeus from bending under the pull of the levator of the labrum-epipharynx.

The Mandibles. Each mandible is a thin, crescentic blade which is suspended from the head capsule with its flat sides facing antero-posteriorly. The blade is slightly concave anteriorly on its distal half. The lateral margin becomes heavier as it approaches the point of articulation. Above this point the mandible is somewhat cylindrical and terminates proximally with its end obliquely truncate (Plate I, figs. A and E; MD.). The latero-posterior aspect of this cylindrical portion is concave so that it forms an angle with the lateral margin of the blade proper. The knob-like projection thus formed serves as the point of articulation between the mandible and the sclerotized, hooklike process of the fronto-clypeus (Plate I, fig. A, MD. COND. and E; MD.). The cylindrical end beyond the point of articulation swings freely in the membrane. This membrane, in which the mandible is suspended, is attached to the upper third of the lateral edge of the mandible.

The mesal edge of the mandible is thin. It is produced into a thin, transparent lamella which increases in area toward the distal end and then decreases rapidly until at the tip of the blade it is gone (Plate I, A;

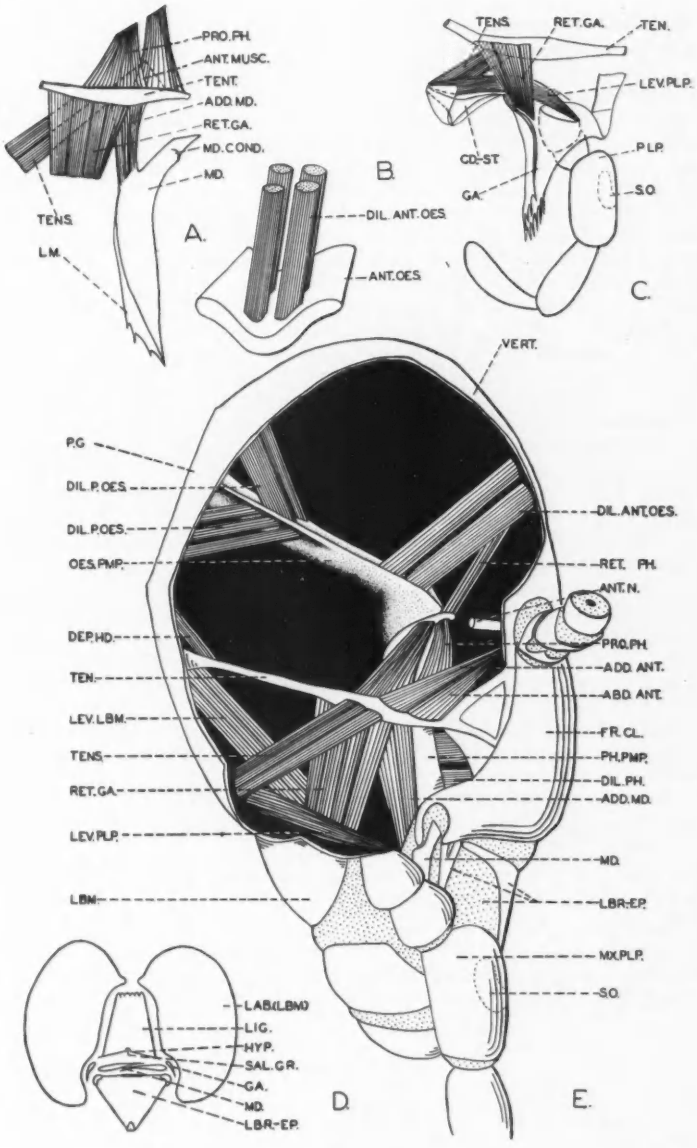
EXPLANATION OF PLATE I

Eusimulium lascivum

A. Mesal aspect of the mandible, tentorium, and associated musculature of female.
B. Anterior portion of the oesophageal pump of female, with its musculature.
C. Mesal aspect of the maxilla, tentorium, and associated musculature of female.
D. Cross-section through the mouthparts of female, at the level of the second labial segment.
E. Lateral aspect of the musculature of the head of female as it appears with a portion of the head wall removed.

EXPLANATION OF ABBREVIATIONS

A. ADD. MD.—Accessory adductor of the mandible.
ABD. ANT.—Abductor of the antenna.
ABD. MD.—Abductor of the mandible.
ADD. ANT.—Adductor of the antenna.
ADD. MD.—Adductor of the mandible.
ANT.—Antenna.
ANT. MUSC.—Antennal muscle.
ANT. N.—Antennal nerve.
ANT. OES.—Anterior oesophageal pump.
ANT. W. PH.—Anterior wall of the pharynx.
CD.-ST.—Cardo and stipes.
COMP. LBR.-EP.—Compressor of the labrum-epipharynx.
DEP. HD.—Depressor of the head.
DIL. ANT. OES.—Dilator of the anterior oesophageal pump.
DIL. PH.—Dilator of the pharyngeal pump.
DIL. P. OES.—Dilator of the posterior oesophageal pump.
DIL. SAL. PMP.—Dilator of the salivary pump.
E.—Eye.
F. M.—Foramen magnum.
FR.-CL.—Fronto-clypeus.
GA.—Galea.
HYP.—Hypopharynx.
LAB.—Labella.
LBM.—Labium.
LBR.-EP.—Labrum-epipharynx.
LEV. LBR.—Levator of the labrum-epipharynx.
LEV. LBR.-EP.—Levator of the labrum-epipharynx.
LEV. LBM.—Levator of the labium.
LEV. PLP.—Levator of the maxillary palpi.
LIG.—Ligula.
LM.—Lamella.
MD.—Mandible.
MD. COND.—Mandibular condyle.
MX. PLP.—Maxillary palp.
OC.—Occiput.
OC. CON.—Occiputal condyle.
OES. PMP.—Oesophageal pump.
O. LEV. PLP.—Origin of the levator of the palp.
PED.—Pedicel.
P. G.—Postgena.
PH. PMP.—Pharyngeal pump.
PLP.—Maxillary palp.
P. OES.—Posterior oesophageal pump.
PRO. PH.—Protractor of the pharyngeal pump.
P. W. PH.—Posterior wall of the pharynx.
RET. GA.—Retractor of the galea.
RET. PH.—Retractor of the pharyngeal pump.
SAL. CH.—Salivary channel.
SAL. D.—Salivary duct.
SAL. G.—Salivary gland.
SAL. GR.—Salivary groove.
SAL. PMP.—Salivary pump.
SC.—Scape.
S. O.—Sensory organ.
TENS.—Tensor muscle.
TENS. FR.-CL.—Tensor of the fronto-clypeus.
TEN.—Tentorium.
TENT.—Tentorium.
TH.—Theca.
VERT.—Vertex.


PRO.PH.
ANT.MUSC.
TENT.
ADD.MD.
RET.GA.
MD.COND.
MD.
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A.
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ANT.OES.
TENS.
RET.GA.
TEN.
LEV.PLP.
CD-ST
GA.
PLP.
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C.
VERT.
P.G.
DIL.P.OES.
DIL.P.OES.
OES.PMP.
DEP.HD.
TEN.
LEV.LBM.
TENS.
RET.GA.
LEV.PLP.
LBM.
DIL.ANT.OES.
RET. PH.
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PRO.PH.
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ABD.ANT.
FR.CL.
PH.PMP.
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LAB.(LBM)
LIG.
HYP.
SAL.GR.
GA.
MD.
LBR-EP.
D.
E.

LM.). In several places along its widest part it is further produced into a few short serrations. The lamella begins below the insertion of the adductor muscle of the mandible (Pl. I, fig. A; ADD. MD.).

Musculature. In *Eusimulium lascivum* the mandible is served by only one muscle, the adductor. It arises on the inner, lower side of the anterior arm of the tentorium below the origin of the antennal muscles and before that of the retractor of the galea. It is inserted on the mesal edge of the mandible about one fourth of the distance from the proximal end (Plate I, figs. A and E; ADD. MD.).

In *Prosimulium magnum* there are two additional muscles. One of these is the abductor of the mandible. Its origin is on the postgena. It tapers sharply, the apex giving rise to a long tendon which is inserted on the proximal end of the mandible (Plate II, fig. F; ABD. MD.). The other is an adductor of the mandible. It arises on the postgena above the abductor. Like the abductor it tapers and gives rise to a long tendon which runs across the mesal face of the abductor muscle and is inserted on the mesal edge of the mandible below the insertion of the other adductor which latter corresponds to the adductor of the mandible of *E. lascivum* (Plate II, fig. F; ADD. MD.; A. ADD. MD.). In *E. lascicum* the two large muscles are not present although there was a vestige of the abductor muscle in one dissection.

The Maxillae. Each maxilla consists of a palpus, a galea, and what appears to be the fused cardo and stipes (Plate I, fig. C; II, fig. E). These parts are joined together by the membrane which is common to all the mouthparts. The sclerites of the fused cardo and stipes are attached to the posterior wall of the head capsule above the attachment of the labium. Each is surrounded laterally and dorsally by the postgena, (Plate II, fig. E; CD.-ST.). The anterior extension of the fused sclerites of each side is joined to the membrane which binds the first segment of the palpus to the head capsule and which is continuous with the proximal end of the galea (Plate II, fig. E).

The palpus is four segmented with the first segment subdivided. The second segment has a deep pit in which is probably located a sensory organ, (Plate I, figs. C, E; S. O.).

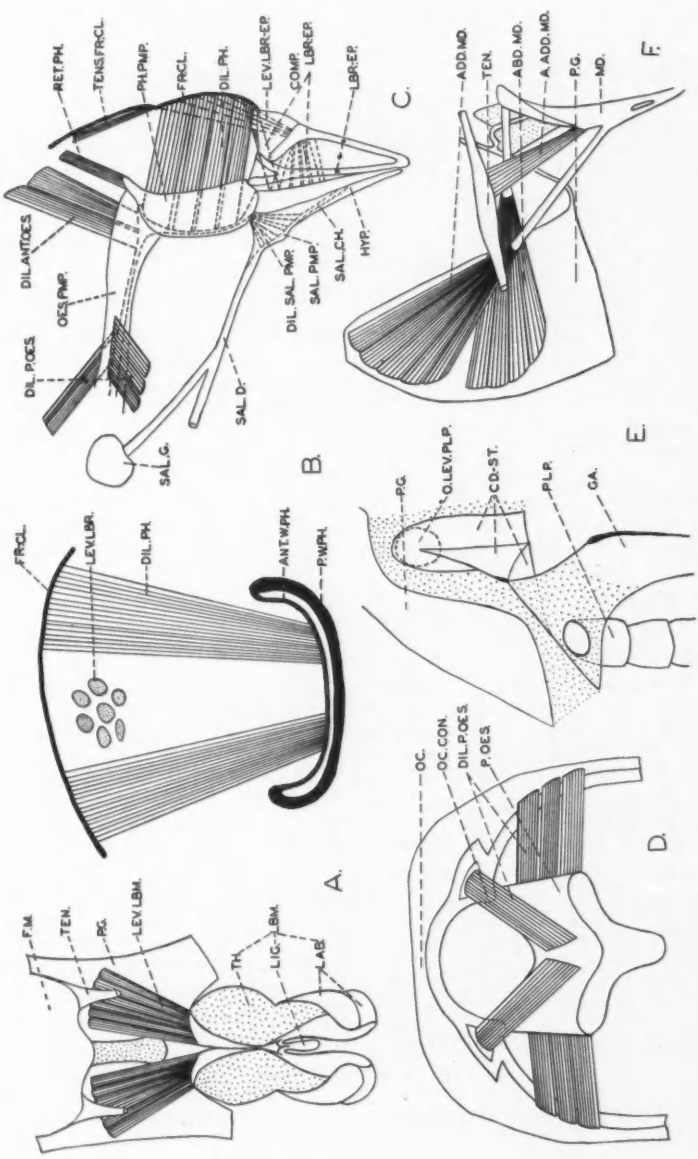
The galea is bladelike and strongly concave anteriorly. It tapers gradually from its proximal end to the distal and terminates in a rounded point armed with spinelike projections, (Plate I, fig. C; GA.).

EXPLANATION OF PLATE II

Figs. A–E, *Eusimulium lascivum*

Fig. F, *Prosimulium magnum*

A. Cephalic aspect of the labium and associated musculature of female.
B. Cross-section through the pharyngeal pump, one pair of dilator muscles, and the levator muscle of the labrum of female.
C. Lateral aspect of the pharyngeal pump, oesophageal pump, salivary pump, one salivary gland, hypopharynx, labrum-epipharynx, and the associated musculature with the exception of the protractor muscles of the pharyngeal pump of female.
D. Posterior portion of the oesophageal pump of female with its musculature.
E. Cephalic aspect of the maxilla of female with the musculature removed.
F. Mesal aspect of the mandible and tentorium of *Prosimulium magnum* (female) with its associated musculature.


RET.PH.
TENS.FRCL.
PH.PMP.
FRCL.
DIL.PH.
LEV.LBR.EP.
COMP.
LBR.EP.
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DILANTOES
OES.PMP.
DIL.POES.
DIL.SAL.PMP.
SAL.PMP.
SAL.CH.
HYP.
SAL.D.
SAL.G.
B.
C.
ADD.MD.
TEN.
ABD.MD.
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LEV.LBR.
DIL.PH.
ANT.WPH.
P.WPH.
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P.G.
O.LEV.PLP.
CO-ST.
P.LR.
GA.
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OC.CON.
DIL.P.OES.
P.OES.
D.
F.M.
TEN.
PG.
LEV.LBM.
TH.
LIG.
LBM.
LAB.

Musculature. The levator muscle of the palpus arises on the upper end of the fused cardo and stipes at the point of junction with the head capsule (Plate II, fig. E; O. LEV. PLP.). It is inserted on the upper anterior edge of the first segment of the palpus at the line of its junction with the membrane (Plate I, figs. C and E; LEV. PLP.).

The retractor muscle of the galea is a broad group of short muscles whose origin is on the inner and under side of the tentorium posterior to the origin of the adductor of the mandible. It is inserted near the mesal edge of the proximal end of the blade (Plate I, figs. C and E; RET. GA.).

A muscle associated with the maxillary musculature takes its origin on the lateral face of the tentorium beside the origin of the retractor of the galea. It is inserted on the head capsule above and laterad to the origin of the levator of the palpus (Plate I; figs. C and E; TENS.).

The Labium. The labium consists of two lobes each of which is concave anteriorly, especially at the distal two thirds, so that the other mouthparts are concealed therein when at rest (Plate I; fig. E; II; fig. A; LBM.). Each lobe is composed of three segments. The proximal segment of one lobe is fused to that of the other along the posterior midline, while the remaining segments lie free. According to Jobling (1928) the fused basal segments constitute the theca while the free segments are the labella (Plate II; fig. A; TH., LAB.). At the inner distal ends of the proximal segments lies the ligula (Plate II; fig. A; LIG.).

Musculature. Each lobe of the labium is provided with a single muscle. The muscle for each lobe arises on the postgena below the posterior arm of the tentorium and is inserted on the turned in margin of the basal segment (Plate I; fig. E; II, fig. A; LEV. LBM.). This muscle probably acts as the levator of the labium.

The Hypopharynx. The hypopharynx is an elongate, triangular blade. It is suspended from the posterior wall of the pharyngeal pump. The proximal portion of its posterior surface has attached to it the salivary pump (Plate II; fig. C; HYP., SAL. PMP.). The salivary duct pierces diagonally through the hypopharynx and continues along the anterior wall as a groove (Plate I; fig. D; SAL. GR.; II; fig. C; SAL. CH.). The remainder of the posterior wall of the hypopharynx is attached to the ligula of the labium (Plate I; fig. D; LIG.).

THE ANTENNAE

Each antenna is composed of eleven segments and is supplied with two muscles. Both of these take their origin on the dorso-lateral surface of the tentorium. They arise one in front of the other, the anterior slightly overlapping the posterior (Plate I; fig. E; ADD. ANT.; ABD. ANT.). The anterior muscle of the pair is inserted on the lower outer edge of the scape while the other is inserted on the lower inner edge. The first is the abductor of the antenna, the second the adductor. Acting together they would depress the antenna.

THE DEPRESSOR OF THE HEAD

The head is depressed by two long, ribbonlike muscles each of which is inserted on the posterior tentorial arm and arises in the prothorax (Plate I; fig. E; DEP. HD.).

DETAILED DESCRIPTION OF THE PUMPS

The pumps in *Eusimulium lascivum* are the pharyngeal pump, the oesophaegal pump, and the salivary pump. They are all of the same general type in that they are dilated by muscular action and spring back into their normal position by the resiliency of their sclerotized walls.

The Pharyngeal Pump. The pharyngeal pump is a vertical, sclerotized tube lying in the midline of the head just behind the fronto-clypeus (Plate I; fig. E; II; fig. C; PH. PMP.). Its anterior wall is invaginated into the lumen of the pump so that its inner face is almost apposed to that of the posterior wall (Plate II; fig. B; ANT. W. PH.). The anterior wall is continuous with the posterior wall of the labrum-epipharynx at its lower end and with the dorsal wall of the oesophageal pump at its upper end. The posterior wall is continuous with the hypopharynx at its lower end and the ventral wall of the oesophageal pump at its upper end (Plate II; fig. C; PH. PMP.).

Musculature. The pharyngeal pump is served by three groups of muscles; two pairs of protractors, a pair of retractors, and four pairs of dilators. Each pair of protractor muscles of the pharyngeal pump arises on the tentorium beside the origins of the antennal muscles and above those of the adductor of the mandible and retractor of the galea. The pair is inserted on the dorso-lateral edge of the posterior wall of the pharyngeal pump near the line of junction with the oesophageal pump (Plate I; figs A and E; PRO. PH.).

The two retractor muscles of the pharyngeal pump originate on the vertex between the origins of the dilators of the anterior end of the oesophageal pump. Each is inserted on one of the upper anterior corners of the pump (Plate I; fig. E; II; fig. C; RET. PH.).

The dilator muscles of the pharyngeal pump take their origin on the fronto-clypeus and are inserted on the anterior wall of the pump (Plate I; fig. E; II, C; DIL. PH.).

The protraction and retraction of the pharyngeal pump will also cause protraction and retraction of the hypopharynx, and, because of the nature of their attachment, the levation and depression of the labrum-epipharynx.

The Oesophageal Pump. The oseophageal pump continues from the pharyngeal pump at almost a right angle and passes through the brain to the foramen magnum. The pumping portions are in front of and behind the brain (Plate I; fig. E; II; fig. C; OES. PMP.).

The anterior portion of the oesophageal pump has nearly the same cross-sectional structure as the pharyngeal pump, the dorsal wall being almost apposed to the ventral wall (Plate I; figs. B and E; II; fig. C; ANT. OES.). As the pump passes through the brain the cross-sectional structure changes until at its posterior end the dorsal and two lateral walls are invaginated into the lumen forming a somewhat Y-shaped channel in cross section (Plate I; fig. E; II; figs. C and D; P. OES.).

Musculature. The anterior portion of the oesophageal pump is dilated by four muscles whose origins are on the vertex and insertions on the dorsal wall of the pump (Plate I; figs. B and E; II; fig. C; DIL. ANT. OES.).

The posterior portion of the pump is dilated by three muscles. The first, which consists of a group of two, arises on the occiput just above the occipital condyles and is inserted on the dorsal wall of the pump (Plate I; fig. E; II; figs. C and D; DIL. P. OES.). The other two muscles consist of three each. Each group of three originates on the postgena near the edge of the foramen magnum and is inserted on a lateral wall of the pump (Plate I; fig. E; II; figs. C and D; DIL. P. OES.). Dilation would be accomplished by the three muscles pulling in unison.

The Salivary Pump. The salivary pump is a modified and sclerotized portion of the common salivary duct before it passes into the hypopharynx. The duct is dilated and has the upper wall invaginated into the lumen. The lateral edges formed by this invagination are attached to the hypopharynx (Plate II; fig. C; SAL. PMP.). The dilator muscle of the salivary pump arises on the midline of the lower end of the posterior wall of the pharyngeal pump. It is inserted on the invaginated wall of the pump (Plate II; fig. C; DIL. SAL. PMP.).

Summary

The author has studied the mouthparts and associated musculature of *Eusimulium lascivum* Twinn. Though the above description is specifically for the female, it would do as well for the male since the two are almost identical in the structures described.

In all there are eighteen groups of muscles which consist of a total of forty-seven individual muscles. These appeared consistently in more than seventy-five dissections. In addition there are some vestigial muscles which occurred only in a few specimens. These vestiges correspond to functional muscles in *Culicoides pulicaris* as described by Jobling (1928), and also to muscles present in *Prosimulium magnum* as studied by the writer. The absence of some of these important muscles, especially the mandibular muscles, seems to indicate that *Eusimulium lascivum* does not take blood.

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A NEW TROGLODERUS FROM NEVADA, WITH A KEY TO THE KNOWN SPECIES
(COLEOPTERA: TENEBRIONIDAE)

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University of Nevada, Reno

The genus *Trogloderus* was erected by Le Conte in 1879, to receive the newly-described *costatus* from Idaho. In 1883, Le Conte and Horn erroneously restricted the species to "Nevada," but Dr. Blaisdell, in 1909, extended the distribution to "Western Nevada and the contiguous eastern California." In the same publication, Dr. Blaisdell described a new species, *tuberculatus*, from a single specimen in the U. S. National Museum from Los Angeles County, California.

While collecting over the sand dunes of northern and central Nevada during the summer of 1941, the author took ten individuals of an undescribed species which, from present meager observations, seems to be restricted to sanded areas. The following key (adapted from Blaisdell, 1909) will separate the three species of the genus:

Pronotum tuberculate ..... **tuberculatus**
Pronotum reticulate.
  Pronotal median foveae deep, distinct, separate; larger, averaging 11.5 mm. **costatus**
  Pronotal median foveae absent or faint and connected, appearing as a shallow furrow; smaller, averaging 9.1 mm ..... **nevadus**

The author wishes, at this point, to acknowledge his indebtedness to Dr. Blaisdell, whose generous and kindly aid has made possible the following account.

Trogloderus tuberculatus Blaisdell

Trogloderus tuberculatus Blaisdell, 1909, U. S. N. M. Bul. 63, pp. 490–492; pl. 6, fig. 14.

This distinctive species, described from a solitary female collected by D. W. Coquillett in Los Angeles County, California, has since been found in two other states. Seven specimens in the collection of the California Academy of Sciences represent four new localities:

Nineteen miles southwest of Kayenta, Navajo County, Arizona, at 6,500 feet, two specimens collected June 17, 1933, and one on June 18, 1933, by H. N. Hultgren, of the Ansel F.

Hall Expedition, 1933; Mojave, California, one specimen in the Van Dyke collection, taken May 1, 1937; Willow Tank, Escalante Desert, Kane County, Utah, two specimens collected during June of 1936, by V. M. Tanner; Utah, one specimen in the Fenyes collection, taken in August of ?.

Like *costatus*, this species possesses two well-defined median foveae on the pronotum, and none of the specimens examined showed any tendency towards foveal obliteration or coalescence.

Trogloderus costatus Le Conte

Trogloderus costatus Le Conte, 1879, N. A. Entomologist, January 1, p. 3; pl. 1, fig. 3.

In his description of the species, Le Conte listed the following specimens: "Rock Creek, Owyhee County, Idaho. Mr. Charles Lichtenfeld; one specimen kindly given me by Mr. Reinecke; others are in the collections of Dr. Horn and Mr. Bolter." The California Academy of Sciences collection contains the following records: Wendall—Gooding, Idaho, one specimen collected on April 5, 1931, by J. C. Chamberlin: Lake Tahoe, California, two specimens collected on July 4, 1941, by Kenneth S. Hagen; Truckee, California, one specimen taken at the State quarantine station by inspectors, a specimen which may have come from adjacent Nevada.

The author has Nevada specimens from Douglas County (Minden), Humboldt County (Paradise Valley sand dunes), Washoe County (Truckee Meadows, Washoe Lake dunes). In the vicinity of Reno (Truckee Meadows), the species is taken most frequently along river bottoms during moderate winters while they are hibernating, and practically all specimens so collected are encrusted to some degree with mud, which usually obliterates the finer, and sometimes all, sculptural details. In 1909, Dr. Blaisdell could only record the species' habitat as "arid regions," but information accumulating since then indicates that *costatus* is equally at home in more humid situations; in fact, as mentioned above, they occur, as accurately as three years of collecting can determine, only along streamways in the vicinity of Reno, where the author is most familiar with the species. Specimens from Minden were taken in equally moist situations near the eastern face of the Sierra Nevada Mountains. Individuals from the sanded northeast side of Washoe Lake, and from the sand dunes in the southwest corner of Paradise Valley, however, were inhabitants of typically

arid regions. The Paradise Valley specimens were taken only on the shaded, eastern edge of the dunes in late afternoon, where they were feeding on shrubs and characteristic annuals of the dunes, associated with *Sphaeriontis muricata*, *Eleodes obscura sulcipennis*, *E. longipilosa*, *E. nigrina*, and *E. pilosa*. The associated streamway fauna, as would be expected, presents a different facies, and is distinguished by such species as *Eleodes tenebrosa tenebrosa*, *E. t. nana*, *E. pilosa*, *E. nigrina*, *Helops californicus*, *Platystinus crassicornis*, *Calendra vomerina*, and *Cardiophorus fenestratus*.

Trogloderus nevadus n. sp.

The following description is patterned after the form established by Dr. Blaisdell.

General: Elongate, oblong-oval, opaque, reddish-brown to purple-black; pronotum reticulate; elytral costae acutely elevated; total length 8 mm. to 11 mm.

Head: Rough, irregularly impressed to smooth, tuberculate; frontal ridge weak to prominent, arcuate, connecting antennal bases; median, longitudinal head ridge single, weak, wide to double, parallel, strong, and narrow, flanked by weak depressions which extend laterally almost to the eyes.

In two specimens, the head is typically rough and irregularly impressed. The remainder possess a smoother surface, dotted to varying extents with small tubercles. The smoothest example possesses a perfectly clear, narrow strip bordering the weak frontal ridge posteriorly, the remainder of the head beset with small tubercles, while the median ridge is obsolete. Several individuals show the median ridge suppressed into two parallel, thin but definite, ridges which bow laterally, forming two isolated, concavely-opposed crescents occupying the center of the head, the intervening and flanking areas being relatively smooth, while the frontal ridge is prominent, and the epistoma more or less hourglass-shaped, each end scooped out, the entire plate weakly tuberculate. In the fourteen specimens examined, the head varies from 2.7% longer than wide to 33.4% wider than long, the average being 17.2% wider than long.

Pronotum: Widest at the middle, disc strongly convex in transverse section, finely reticulate, each reticule generally possessing a minute puncture. Two median foveae entirely absent or reduced to faint, connected depressions, forming a weak, longitudinal furrow extending from the anterior edge of the pronotum three-fourths of the distance to the posterior edge. Pronotal margins reflexed, most prominently along posterior, arcuate border. Lateral margins serrate anteriorly, roughened posteriorly, and entire margin darker than disc.

In two of the specimens, a coalescing of the reticules was noted, especially in the anterior central portion of the disc, and in one individual, a slightly widened posterior end of the median furrow suggests

the large, hind fovea of *costatus;* in another specimen, the furrow is obliterated except for a slight suggestion of the anterior *costatus* fovea, and effect produced by the fusion of several reticules, thus eliminating the intervening ridges and forming a very faint depression. Such characters, however, are visible only under strong magnification. In the specimens examined (14), the pronotum varies from 13.7% to 24.8% wider than long, averaging 18.1%.

Elytra: Widest at, or slightly forward of, middle; base lacking margin, and slightly narrower than opposed prothoracic margin; humeri obsolete; disc strongly convex in transverse section, sutural costae weak, not equalling strongly developed discal and humeral costae, which are weakly and widely serrate on top, the teeth pointing caudad, and each tooth bearing a tiny seta at the posterior base; intercostal spaces weakly punctate; all costae ending free at apical declivity, humeral costae not distinctly longer than remaining costae. The elytra varies from 31.3% to 42.9% longer than wide, averaging 35.3%.

Propleurae: More systematically punctate than the intercostal spaces, the punctures arranged in distinct longitudinal lines. Otherwise smooth and slightly convex in transverse and longitudinal sections.

Ventrum: Nearly smooth, weakly beset with fine, widely-spaced tubercles.

Legs: Smoother, but similar in all points to *costatus* (see Blaisdell, 1909).

Male—The solitary male in the lot is 8 mm. long; profemora armed with a low, blunt tooth distally, protibiae bearing a wide, broad tooth proximally, giving the segment the appearance of being rapidly constricted near the base.

Females—Vary in size from 8 to 11 mm., averaging 9.3 mm. in length; only one specimen measured 8 mm., the remainder being larger than the solitary male; profemora and protibiae obsoletely toothed.

Genitalia: Similar to *costatus*, but smaller, the solitary male *nevadus* apicale comparatively shorter, being only 34.7% of the total edeagophore length, while *costatus* apicales examined average 40% of the total edeagophore length, none being less than 39.4%.

Affinities: Trogloderus nevadus exhibits close relationship to *T. costatus*, especially specimens of the latter collected at the Paradise Valley dunes. These dune *costatus* approach *nevadus* in finer sculpturing and smaller foveae, but none exhibit typical *nevadus* details, such as fused, obsolescent foveae and elytral punctation. It is possible that a larger series of *nevadus* might show forms intergrading with *costatus*, for there is much of Nevada which has yet to be collected over, but the fourteen specimens studied exhibit distinct specific characters, and could not be confused with even the dune *costatus*. Quite obviously, *nevadus* is a specialized *costatus*, apparently isolated from that species at one time by the vagaries of the inland seas and lakes

which have occupied the Great Basin in the geologic past. Now, however, with the vanishing of the isolating factor, the two species have again come in contact, a line of contact which has so far been demonstrated only in regions occupied by dunes and loose sands.

Habitat: West central and southern Nevada, apparently restricted to sand dune areas. The following localities have yielded specimens: Paradise Valley sand dunes, one specimen, taken on June 18, 1941, by Ira La Rivers (Calif. Acad. Sci. col.); Pyramid Lake sand dunes, seven specimens (one male, six females, September 1, 1941, Ira La Rivers and Thomas Trelease (author's col.); Pyramid Lake, one specimen, collected May 19, 1923, in Blaisdell Collection (Calif. Acad Sci. col.); Truckee, California, four specimens taken at the State quarantine station by inspectors (one on March 3, 1930), and donated by G. R. Wilson. From available evidence, it is very probable that these came from adjacent Nevada (Calif. Acad. Sci. col.); Thorne sand dunes (Mineral County), two specimens, July 7, 1941, Ira La Rivers, (one in author's col., other in Calif. Acad. Sci. col.); Esmeralda County, one specimen, March 19, 1908, F. W. Nunenmacher, in Van Dyke Collection (Calif. Acad. Sci. col.); Goldfield, Esmeralda County, one specimen, June 26, 1907, F. W. Nunenmacher, in Blaisdell Collection (Calif. Acad. Sci. col.).

Types: Holotypic male (Pyramid Lake), allotype (Thorne), and four paratypes (Pyramid Lake), in the author's collection; four paratypes in the collection of the California Academy of Sciences; one paratype each in the collections of the U. S. National Museum and the American Museum of Natural History.

Habits: Practically nothing is known of the life history of the species. They possess, in common with the *T. costatus* collected in similar arid situations, the habit of rigidly feigning death when disturbed, and all the specimens taken were observed to place the middle legs fixedly at right angles to the longitudinal axis of the body, disposing the other two pairs of legs so each formed an approximate 45 degree angle with the middle legs and body. At Pyramid Lake, *T. nevadus* was found associated with *Sphaeriontis muricata*, *Eleodes armata*, *E. grandicollis valida*, *Cryptoglossa verrucosa inyoensis*, and *Blapstinus crassicornis*, with similar associations at Thorne. At the Paradise Valley sand dunes, *nevadus* was found with *costatus*, the only

region in which the association of the species has been demonstrated.

Russian thistle (*Salsola pestifer*) grows prolifically on the low Pyramid Lake dunes, and many of the characteristic dune inhabitants use the weed for food and shelter. Like the others, *nevadus* avoids the heat of day, and is most in evidence in the late afternoon on the shady (east) side of the dunes.

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STUDIES IN THE GENETICS OF DROSOPHILA. II. GENE VARIATION AND EVOLUTION. Directed by JOHN T. PATTERSON. pp. 1–200, 7 x 10 inches, paper bound. The University of Texas Publication, No. 4228. Published by THE UNIVERSITY OF TEXAS, Austin, Texas. Price $1.00.

The first publication in this series, which appeared in 1940, dealt primarily with the effects of aneuploidy and chromosomal aberration on the phenotype, viability, and fecundity of *Drosophila;* the present publication consists of ten papers dealing with gene variation and evolution, written by various members of the group working in the genetics laboratory of the University of Texas.

The scope of this publication is indicated by the paper titles: Interspecific hybridization in the genus *Drosophila;* Heterosis in *Drosophila hydei;* Analysis of the *repleta* group of *Drosophila;* Cross fertilization and isolating mechanisms in the *Drosophila mulleri* group; Relationships in the *melanica* species group; Genetic relationships in the *Drosophila funebris* group; A study of intersexes produced by a dominant mutation in *Drosophila virilis, blanco* stock; The Ix^B factor and sex determination; Distribution of the *virilis* group in the United States; Genetic and cytological analysis of the *virilis* species group.

This publication should be of interest to entomologists in that it presents a detailed analyses of some of the genetic factors that have been in operation in the evolution of the flies of the genus *Drosophila.* Few entomologists can experiment with their material to the extent that geneticists have done with *Drosophila,* but an understanding of the processes at work in *Drosophila* may help to clarify the problems encountered in other animal groups.—D. J. BORROR.

NOTES ON TABANIDAE (DIPT.) FROM PANAMA

X.[1] THE GENUS TABANUS LINN., AND RESUME OF THE TABANIDAE OF PANAMA[2]

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Genus **Tabanus** Linnaeus

1758, Syst. Nat., 10th ed., p. 601. Latreille, 1810, Consider. General, p. 443 (Type, *T. bovinus* Linn.). Kertész, 1908, Cat. Dipt., III, p. 217. Surcouf, 1921, Gen. Insect., Fasc. 175, Taban., p. 54. Enderlein, 1922, Mitt. Mus. Berlin, X, 2, p. 347; Op. cit., 1925, XI, 2, p. 355. Bequaert, 1930, The African Republic of Liberia and the Belgian Congo, II, p. 903. Kröber, 1934, Rev. Ent., IV, 3, p. 292.

There seems no good reason for including the many references to the name to be found in the literature, nor do I feel it wise to list the numerous names which have been placed in the synonymy of *Tabanus* by various authors. Names in this group are being removed from and replaced in the synonymy so often that it seems better not to further complicate matters.

A single species, *T. globulicallosus* Kröber (Stett. Ent. Zeit., XCII, p. 302) has been omitted, as, although described from Panama, I have been unable to recognize it from the description.

KEY TO SUBGENERA OF TABANUS

1. Pre-scutellum and disc of scutellum densely covered with black pubescence which is more or less completely surrounded by a ring of white pubescence. Eyes bare. Vertexal tubercle weakly developed or absent in the female, present in the male. . . . . **Bellardia**
   No black pile on scutellum, rarely a small tuft on pre-scutellum. 2
2. Wings prominently clouded with brown, rarely largely black, generally with the cross-veins surrounded by hyaline fenestrae. Frons mostly very narrow, the callus ridge like. Eyes bare, unbanded in life, **Philipotabanus**
   Wings fumose, hyaline, entirely black or spotted on the cross veins, or frons otherwise. 3
3. Abdomen with 1 or 3 pale longitudinal stripes or rows of truncate contiguous triangles. Fore tibiae bicolored. Eyes bare in the female, bare or hairy in the male, green with 2 or 3 dark bands in life. Wings hyaline, fumose or with faint clouds on cross veins. . . . . **Neotabanus**
   Abdomen unstriped, or eye with but one band in life. 4
4. Eyes definitely pilose in both sexes, generally dark with 2 or more green bands in life. Vertexal tubercle present, usually prominent. . . . . **Hybomitra**
   Eyes bare in the female, or vertexal tubercle absent. . . . . **Tabanus**

[1] Part IX these Annals, September, 1942, p. 289.
[2] Printing costs paid in full by the Gorgas Memorial Institute, Washington, D. C.

KEY TO FEMALES OF TABANUS

1. Wholly black species with deep black wings. Third antennal segment with a rather long tooth dorsally and a prominent angle below. Large species 20 mm. or more long.....**erebus**
Not black species, the wings hyaline or fumose.....2
2. Prescutellum with a small tuft of black pubescence. Large brown species mostly over 15 mm. long, the antennae with a strong dorsal tooth, the abdomen with 2 or 3 rows of light spots.....3
Prescutellum concolorous with rest of thorax.....4
3. Palpi exceedingly short and thick. Abdomen brown, dark haired, but with a pair of pale haired dorsolateral stripes formed of large confluent rounded spots extending from the first to sixth tergites.....**importunus**
Palpi stout, but the apex drawn out into a slender point. Abdomen with a median series of pale haired triangles as well as the dorsolateral series, the latter of smaller, less confluent spots.....**ferrifer**
4. Frons very narrow, callus ridge like, third antennal segment with a strong dorsal tooth. Legs black, abdomen orange rufous, the terminal segments often black. Wings strongly smoky. Large species, generally over 15 mm.....**bigoti**
Smaller more slender species, seldom reaching 15 mm. Legs not wholly black. Frons broader, the callus at most club shaped.....5
5. Wings, including the costal cell, entirely hyaline. Frons quite broad, the callus as wide as high.....6
Wings fumose, or the veins brown margined, or the costal cell yellowish or brownish. Frons narrower, the callus generally higher than wide.....7
6. Annulate portion of third antennal segment longer than basal portion. Frontal callus yellow, rounded, rather flat. Thorax grey, rather prominently striped. Abdomen dark with a row of pale grey median triangles and a pair of dorsolateral rows of oblique grey patches.....**praepilatus**
Annulate portion of third antennal segment shorter than basal part. Frontal callus black, rather protuberant. Thorax unstriped. Abdomen yellow, with three rows of faint pale haired spots.....**rhizophorae**
7. Antennae exceedingly slender, the third joint wholly black, with the short dorsal tooth very close to the base. Slender, long winged species, the wings evenly fumose, the abdomen brown, with a median row of non-contiguous pale haired triangles.....**umbraticolus**
Smaller, stouter species, the wings with all veins narrowly brown margined, the antennae with third joint largely or wholly yellow, stouter, and the abdomen not so marked.....8
8. Abdomen yellow, dark haired, and with a prominent broad median yellow haired stripe from base to apex, rarely with indications of faint lateral stripes.....**rixator**
Abdomen dirty brownish yellow, with three very faint narrow pale haired stripes.....**nereus**

Tabanus bigoti Bellardi

(Figs. 4 and 5)

1859, Sagg. Ditt. Mess., I, pp. 58–59 (New name for *T. apicalis* Macq. 1847, nec. Wied. 1828. Description drawn from Macquart's type specimen, which was headless). Osten Sacken, 1886, Biol. Centr.-Amer., Dipt., I, p. 48 (♀; Nicaragua). Hine, 1925, Occ. Pap. Mus. Zool. Univ. Michigan, No. 162, p. 29 (♀; Honduras).

Tabanus apicalis Macquart, 1847, Mém. Soc. Sci. Lille, (1846), p. 36; 1847, Dipt. Exot., Suppl. II, p. 20 (♀; du Mexique). Not *T. apicalis* Wied. 1828.

Tabanus appretiatus Kröber, 1934, Rev. Ent., IV, 3, p. 306 (New name for *T. apicalis* Macq. 1847).

Under this name I include provisionally the species occurring in Panama. There seem to be two very similar forms, but their proper relationships cannot be worked out until much more

material from both South and Central America is available. The two forms may be separated as follows:

Antennae largely reddish. Pollinosity of face and frons, and beard yellowish brown. Frontal callus brown. Upper branch of third vein with a long appendix.....form A

Antennae largely black. Pollinosity of face and frons, and beard greyish or white. Frontal callus black. Upper branch of third vein without an appendix.....form B

Which, if either, of these forms is true *bigoti* it is impossible to say. I have seen specimens very similar to both forms from Honduras and Mexico.

Panama records: Form A. El Valle, Coclé Province, April 13, 1941; May 3, 1942; Cerro Campana, Panama Prov., June 11, 1939; Rio Pequeni, Madden Lake, C. Z., Aug. 21, 1940; Cerro Pirre, Darien Prov., March 18, 1940; Buena Vista, Chiriqui Mt., March, 1926 (J. D. Smith). Form B. Cerro Azul, Panama Prov., May 17, 1941.

Tabanus erebus Osten Sacken

(Fig. 1)

1886, Biol. Centr.-Amer., Dipt., I, p. 50 (♀; Nicaragua and Chiriqui Volcano, Panama). Kertész, 1900, Cat. Taban., p. 48. Williston, 1901, Biol. Centr.-Amer., Dipt., Suppl. p. 257. Aldrich, 1905, Cat. N. Amer. Dipt., p. 203. Kertész, 1908, Cat. Dipt., III, p. 240. Surcouf, 1921, Gen. Insect., Taban., p. 67. Kröber, 1930, Zool. Anz., LXXXVI, p. 298 (=? *Catachlorops* sp.); 1934, Rev. Ent., IV, 3, p. 304 (=? *Phaeotabanus alteripennis* Wlk.).

Astigmatophthalmus satanus Kröber, 1931, Rev. Ent., I, 3, p. 297, fig. 11 (♀; Turrialba, Costa Rica and Chiriqui, Panama); 1934, Op. cit., IV, 2, p. 270. Stone, 1938, U. S. Dept. Agric., Misc. Publ. No. 305, p. 88.

This species is one of the largest in our fauna, and is readily recognized by its wholly black color, including the wings. It seems to be related to the North American *T. atratus* Fab., to which Osten Sacken compared it, and might with some justice be combined with that and related species into a group of subgeneric rank, were it not for a number of species which form perfect intergrades with a large and rather heterogeneous complex of South American forms which are as yet poorly known.

The antennal tooth is very variable in length, and may even reach the first terminal annulus.

Distribution: Recorded from Nicaragua, Costa Rica and Panama. I have seen 6 ♀ from Costa Rica in the Hine Coll.

Panama records: 1 ♀ Barro Colorado Is., May 10, 1926 (Greene); 1 ♀ Cabima, Panama, May 20, 1911 (Busck). 5 ♀ Rio Pequeni, May 11, 1940. 1 ♀ El Valle, Coclé Prov., April 13, 1941. 1 ♀ Cerro Azul, nr. Pacora, May 17, 1941. 2 ♀ El Valle, Coclé Prov., May 3, 1942.

Tabanus ferrifer Walker

(Fig. 3)

1850, Insect. Saund., I, Dipt., p. 30 (♀; ? Barbadoes); 1854, List Dipt. Brit. Mus., V, Suppl. 1, p. 189. Osten Sacken, 1858, Cat. Dipt. N. Amer., p. 21; 1876, Mem. Boston Soc. Nat. Hist., II, pt. 4 (4), p. 476; 1878, Cat. Dipt. N. Amer., 2nd ed., p. 61. Kertész, 1900, Cat. Taban., p. 49. Aldrich, 1905, Cat. N. Amer. Dipt. p. 203. Kertész, 1908, Cat. Dipt., III, p. 241. Surcouf, 1921, Gen. Insect., Taban., p. 68. Dunn, 1929, Am. J. Trop. Med., IX, 6, p. 501 (Baranquilla, Colombia).

Tabanus (*Lophotabanus*) *ferrifer* Kröber, 1930, Zool. Anz., LXXXVI, pp. 262–263, fig. 7 (♀; Venezuela); 1934, Rev. Ent., IV, 3. p. 295 (Barbadoes, Panama, Colombia, Venezuela). Bequaert, 1940, Rev. Ent., XI, 1–2, pp. 298–299, fig. 3; 1940, Bull. Ent. Res., XXX, 4, p. 449 (Trinidad).

Tabanus (*Lophotabanus*) *druyvesteijni* Szilàdy, 1926, Biol. Hung., I, (7) p. 26, Pl. 4, fig. 20 (♂, ♀; Trinidad, Surinam, Panama). Kröber, 1929, Zool. Anz. LXXXIII, pp. 130–131, fig. 10 (Venezuela, Panama, Trinidad, Surinam, Bolivia, Paraguay, Argentina); 1930, Op. cit., LXXXVI, p. 263; 1934, Rev. Ent., IV, 3, p. 295.

Hybostraba ornativentris Kröber, 1929, Konowia, VIII, p. 182, Pl. II, figs. 10, 11. (as synonym of *T.* (*L.*) *druyvesteijni*).

This species and *T. importunus* Wied. appear to be related on the one hand to the subgenus *Bellardia* (*Lophotabanus* Szil.) and on the other hand to a large group of South American species whose relationships are as yet not worked out. *Ferrifer* is fairly abundant in Panama where it flies mainly during the dry season, and on account of its large size constitutes a serious stock pest.

Distribution: I have seen material from British Honduras, Panama, Trinidad, Venezuela and Pará, Brazil. The species is also recorded from Bolivia, Paraguay and Argentina, but all material from that area I have seen personally is a distinct though closely allied species.

Panama records: El Real, Darien Prov., to Capira, Panama Prov., mostly in April, May and June, but scattered captures in Nov., Dec., Jan., Feb., July and August. Apparently quite abundant nearly everywhere.

Tabanus importunus Wiedemann

(Fig. 2)

1828, Auss. Zweifl. Insekt., I, p. 127 (♀; Brasil). Walker, 1854, List Dipt. Brit. Mus., V, p. 219. Kertész, 1900, Cat. Taban., p. 54. Lutz, 1912, Comm. Lin. Teleg. Matto Grosso, Zool., Annexo, 5, p. 4; 1909, Inst. Osw. Cruz em Manguinhos, p. 30. Surcouf, 1921, Gen. Insect., Taban., p. 71. Kröber, 1929, Ann. Mus. Wien, XLIII, p. 246; 1934, Rev. Ent., IV. 3, p. 310. Lutz, 1914, Mem. Inst. Osw. Cruz, VI, 2, p. 70. Fischer, 1933, Rev. Ent., III, 1, p. 134.

Odontotabanus importunus Lutz, 1928, Est. Zool. Parasit. Venezolanas, p. 57. (Venezuela).

Tabanus albidicollis Macquart, 1850, Dipt. Exot., Suppl. IV, p. 32 (Guyana).

Tabanus semisordidus Walker, 1854, List Dipt. Brit. Mus., V, p. 208 (♀; Santarem, Brasil).

This species appears to be fairly abundant locally in the

Republic, though its season of flight, from March to May is rather short.

Distribution: I have seen specimens from the Brazilian states of Amazonas, Pará, Rio de Janeiro and Matto Grosso, and from Paraguay, Venezuela, Surinam and British Guiana. Kröber records it also from Peru.

Panama records: Moja Pollo, Chagres River region, March to May 1940, fairly abundant. 1 ♀ Moja Pollo, Sept. 1, 1940.

Tabanus praepilatus sp. nov.

(Fig. 11)

Female.—Length 11–16 mm., of wing, 11–14 mm.

Eyes bare, dull greenish with a single transverse narrow dark stripe which does not reach the lateral eye margin. Frons broad, about 3¼ times as high as wide, convergent,below, pale yellowish grey pollinose. Frontal callus nearly circular, narrower than frons, yellow to dark brown. Median callus a short unconnected streak, sometimes obsolete. No vertexal tubercle or spot. Subcallus yellowish pollinose, without tubercle or spot, and without erect hairs. Fronto-clypeus and genae greyish pollinose, the latter sparsely white bearded beneath. First two antennal segments straw colored, black haired, not inflated. Basal part of third segment dull brownish, nearly as wide as long, the dorsal angle rather obtuse but with a rather sharp apex. Annulate portion blackish, considerably longer than basal portion. Palpi whitish, dorsally black haired, moderately inflated basally, but slender and pointed apically. Proboscis brown, the labella membranous, short, hardly half length of proboscis.

Mesonotum pale brown with three fairly distinct stripes and the sides grey haired. Scutellum concolorous, grey haired. Pleura and coxae pale grey, white haired. Legs pale brown, whitish pollinose and pale haired, tarsi darker. Wings entirely hyaline; subepaulet with macrotrichia, costa and first vein throughout and subcosta in the middle above with macrotrichia, and often a few hairs on the base of the second vein. Beneath only the costa and subcosta are setose. No appendix on upper branch of third vein. Abdomen greyish brown, black haired, and with a row of rather broad contiguous grey mid-dorsal truncate triangles, a dorso-lateral row of contiguous oblique grey patches, and the sides and hind margins of the segments grey. Beneath the venter is uniformly pale grey pollinose and whitish haired.

Holotype ♀ and 1 ♀ Paratype from Bejuco, Panama Province, Panama, April 21, 1940. 1 ♀ Paratype, same locality, June 18, 1939. 4 ♀ Paratypes Aguadulce, Coclé Province, Panama, August 10, 1940 (C. M. Johnson coll.); 1 ♀ Corozal, C. Z., June 29, 1911 (A. Busck, in U. S. N. M.). Holotype and 2 Paratypes to be deposited in the M. C. Z., Harvard University, Cambridge, Mass. Other Paratypes in author's coll. and U. S. N. M.

This species appears to have no very close relatives in Panama, but approaches in general appearance certain Nearctic species such as *abactor* Philip and *erythraeus* Big., from which it differs in broader frons, and details of antennal shape and color pattern.

Tabanus nereus sp. nov.

(Fig. 9)

Female.—Length 9–11 mm., of wing, 9.5–10.5 mm.

Eyes bare, in life green with a narrow transverse median band and the lower margin purple. Frons moderately broad, about 3½ times as high as wide, very slightly narrowed below, and covered with yellowish brown pollen. Frontal callus rounded to pear shaped, higher than wide, a little more than half as wide as frons, dull yellow. Median callus a short streak unconnected with the basal callus. Vertexal tubercle entirely absent. Subcallus greyish brown pollinose, without hairs. Fronto-clypeus and genae grey, sparsely white haired. First and second antennal segments moderately inflated, pale brownish, black haired. Basal part of third segment reddish, longer than broad and longer than the concolorous annulate portion; dorsal angle well marked but obtuse. Palpi white, somewhat inflated basally, the apical two thirds very slender, blunt pointed and almost spatulate or clubbed, hairs mostly black and rather long. Proboscis brownish, the membranous labella more than half the length of the proboscis.

Mesonotum dull yellowish brown with a sparse vestiture of yellowish hairs but no distinct stripes. Scutellum concolorous. Pleura, sternum and coxae greyish pollinose and sparsely white haired. Legs pale brown or yellowish, the tarsi dusky. Femora pale haired, tibiae and tarsi dark haired. Wings with subepaulet, costa, subcosta and basal section of fifth vein with macrotrichia above, only costa and subcosta hairy beneath. Wings lightly fumose, all veins narrowly dark margined. No appendix on upper branch of third vein. Abdomen dirty yellowish brown, dark haired, and with three very faint stripes of paler hairs on the first to fifth tergites. Venter pale pinkish grey, immaculate.

Holotype ♀, Thatcher Ferry, Balboa, C. Z., June 27, 1939. 2 ♀ Paratypes, Old Panama, Jan. 2, 1941. This little species, although rather inconspicuous, can be quickly separated from

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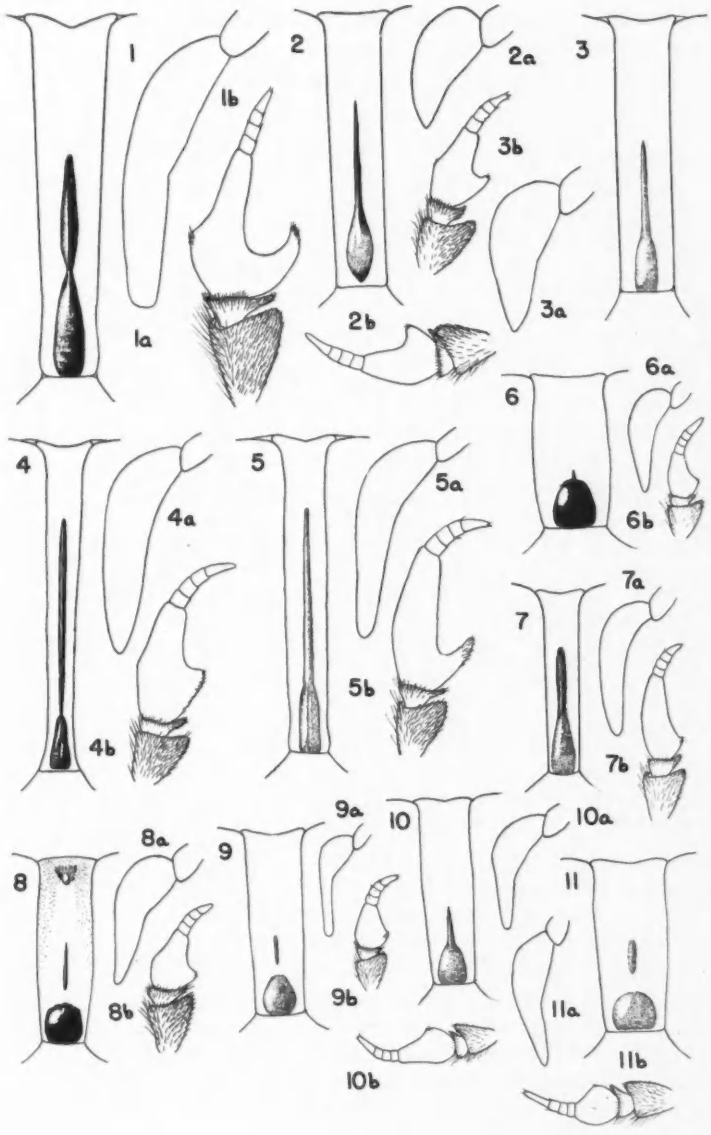
EXPLANATION OF FIGURES IN PLATE I

All figures are of the frons, antennae and palpi of female specimens, and are all to the same scale. The figures of wings are drawn from specimens mounted in balsam, and are to a somewhat smaller scale than the other figures.

Figs. 1, 1a, 1b—*Tabanus erebus* O. S. 2, 2a, 2b—*T. importunus* Wied. 3, 3a, 3b—*T. ferrifer* Walk. 4, 4a, 4b—*T. bigoti* Bell. form B. 5, 5a, 5b—*T. bigoti* Bell. form A. 6, 6a, 6b—*T. rhizophorae* n. sp. Paratype. 7, 7a, 7b—*T. umbraticolus* n. sp. Paratype. 8, 8a, 8b—*T.* (*Hybomitra*) *quadripunctatus* Macq. 9, 9a, 9b—*T. nereus* n. sp. Paratype. 10, 10a, 10b—*T. rixator* n. sp. Paratype. 11, 11a, 11b—*T. praepilatus* n. sp. Paratype.


1
1a
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2b
3
3a
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4a
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5a
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7b
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9a
9b
10
10a
10b
11
11a
11b

its allies by the unusual palpi. It appears to be related to *rhizophorae* and *rixator* and perhaps to the nearctic group of *nigrovittatus*.

Tabanus rixator sp. nov.

(Fig. 10)

Female.—Length 11–12 mm., of wing, 9.5–10 mm.

Eyes bare, in life uniformly yellowish green, without dark markings. Frons yellowish grey pollinose, about 4¼ times as high as basal width, slightly narrowed below. Frontal callus yellow, higher than wide, pear shaped, narrower than frons, and prolonged above in a slender line about its own length. Vertexal tubercle absent. Subcallus yellowish grey pollinose, without hairs. Fronto-clypeus and genae greyish, dark haired above, white haired below. First two antennal segments very moderately inflated, yellowish, black haired. Basal part of third segment reddish orange, longer than wide, the dorsal angle rather prominent and marked by a tuft of black hairs. Annulate portion concolorous, considerably shorter than basal portion. Palpi whitish, inflated basally, but with a slender apex, mostly black haired. Proboscis pale brown, a little longer than palpi, the labella membranes, over ⅔ length of proboscis.

Mesonotum dark grey, yellowish grey pollinose, unstriped. Scutellum concolorous or slightly paler. Pleura, sternum and coxae pale grey pollinose and white haired. Legs wholly pale brown, the femora pale haired, the tibiae and tarsi dark haired. Subepaulet, costa, subcosta and first and fifth veins above with macrotrichia; all veins prominently brown margined. No appendix on upper branch of third vein. Abdomen light yellowish brown, darker towards apex, dark haired and with a fairly broad (.75 mm.) dull yellow middorsal stripe from first to sixth tergites. In well preserved specimens there is also a pair of faint pale dorsolateral stripes formed of a row of small unconnected rounded spots. Venter pale brown, mostly pale haired.

Holotype ♀ and 1 ♀ Paratype, Paitilla Point, Panama, Republic of Panama, July 7, 1940; 1 ♀ Paratype, Venado Beach, Canal Zone, June 22, 1939; 1 ♀ Paratype, Tapia, Panama Prov., Panama, May 5, 1941; 5 ♀ Paratypes, El Real, Darien Prov., Panama, August 15, 1930 (L. H. Dunn); 1 ♀ Paratype, Rio Abajo, Panama Prov., Panama, 1930 (L. H. Dunn).

The relationships of this little species appear to be with the *nigrovittatus* group of North America, it being especially close to *T. fuscicostatus* of Hine, from which the clear costal cell but brown margined veins will distinguish it. It also might be confused with small specimens of *T. haemogogus* Will., but the yellow uniform stripe and unbanded eyes should serve to distinguish the present species.

Tabanus rhizophorae sp. nov.

(Fig. 6)

Female.—Length 11–12 mm., of wing, 9–10 mm.

Eyes bare, unicolorous, blackish with green reflections in life. Frons pale greyish pollinose with scattered dark hairs, about 2⅓ times as high as the basal width, very slightly wider in the middle than at the base and vertex. Basal callus somewhat higher than wide, about ½ the width of the frons, its lower margin contiguous with the basal suture of the frons, and the upper third narrowed into a fine point that may be drawn out into a short fine line, but which never extends more than half way to the vertex. No vertexal tubercle or bare patch. Subcallus whitish pollinose, without hairs. Antennae pale yellowish, the third segment more orange with the annulate portion dusky. First segment markedly swollen, its apex noticeably wider than the basal part of the third segment. Second segment with a dorsal spine, both segments clothed above with black hairs which are especially dense on the dorsal and distal parts. Third segment relatively narrow and with but a weak and obtuse dorsal angle; the annulate portion somewhat shorter than the basal portion. Clypeus and genae straw colored with white pollen and sparse white hairs. Palpi pure white, markedly inflated basally, but with the apical third abruptly narrowed and drawn out into a slender point. Palpi clothed with rather sparse hairs, black and white mixed in about equal proportions. Proboscis short, longer than the palpi but about equal to the antennae, pale brown, the labella fleshy, without shiny plates, and equalling over ⅔ the total length of the proboscis.

Mesonotum dark grey with whitish pollinosity and short, sparse dark hairs. Sides and venter of thorax yellowish grey with abundant white hairs. Scutellum concolorous with mesonotum, or somewhat reddish distally. Wings completely hyaline, the veins and stigma yellowish. Subepaulet rather inflated and beset with black macrotrichia. The costa, subcosta, and first longitudinal vein beyond the arculus above also bear black macrotrichia. All cells but the anal open. No appendix on third vein. All legs entirely straw yellow, the femora with mostly white hairs, the tibiae and tarsi with black.

Abdomen dirty yellowish grey, without prominent markings. The first two segments are more yellowish, the third to last rather dusky with lighter hind margins. In the best preserved specimen the abdomen is clothed with sparse hairs which are for the most part black, but with very small and indistinct patches of pale hairs indicating a median series of spots and a pair of dorsolateral lines. In all the other specimens, these hairs have been rubbed off so that this faint indication of a pattern has been lost. Beneath the abdomen is as above, but with uniformly pale hairs.

Male.—Coloration as in the female, except that the mesonotum has a slight yellowish tinge, and the abdomen shows three fairly distinct longitudinal stripes of yellow hairs. Eyes contiguous, bare, the large facets occupying somewhat more than ½ the total eye area, not sharply differentiated from the small facets, and the largest facets not more than twice the diameter of the smallest. The tubercle at vertex between the eyes is deeply sunk and barely visible.

Holotype ♀, Allotype ♂ and 5 ♀ Paratypes collected by sweeping saltmarsh grass in a small patch of Mangrove trees on the tide flats between Old Panama and San Francisco de la Caleta, Republic of Panama, May 1, 1939. 1 ♀ Paratype, Paitilla Point, Panama, R. de P., Feb. 1, 1929 (C. H. Curran collector); 2 ♀ Paratypes, Paitilla Point near Panama City, July 7, 1940; 2 ♀ Paratypes, Old Panama, April 20, 1940, Jan. 1, 1941; 1 ♂ Paratype, Old Panama, Dec. 24, 1939. Holotype, Allotype and 2 Paratypes to be deposited in the M. C. Z., Harvard University, Cambridge, Mass. 1 Paratype in the U. S. National Museum, 1 Paratype in the American Museum of Natural History and the other Paratypes in the author's collection.

This and two other species described herein seem to form a group of species which appears to be most nearly related to *T. nigrovittatus* and allies of the Nearctic region. Like their Nearctic relatives, they are frequenters of coastal salt marshes.

Tabanus umbraticolus sp. nov.

(Fig. 7)

Female.—Length 13–16 mm., of wing, 13–14 mm.

Eyes bare, dull bronzy in life, without bands. Frons yellowish grey, a little more than 5½ times as high as wide. Frontal callus yellowish brown, drop shaped, merging imperceptibly into a raised ridge which extends about ⅔ the distance to the vertex. Vertexal tubercle absent. Subcallus yellowish grey pollinose, without hairs. Frontoclypeus and genae pale grey, sparsely pale haired. First antennal segment pale yellowish brown, black haired, rather inflated, wider than the base of the third segment. Basal part of third segment over twice as long as greatest breadth, the dorsal angle acute but short, and very close to base. Annulate portion hardly half length of basal portion. Whole third segment, except extreme base, black. Palpi pale brown, slender, black haired. Proboscis dark brown, less than head height, the membranous labella more than half its length.

Mesonotum light brown, very faintly striped. Pleura, sternum and coxae grey pollinose and white haired. Legs pale brown, the fore femora, apices of tibiae and tarsi a little darker. Wings rather long and narrow, pale smoky brown. Subepaulet, costa and first vein with macrotrichia above, subcosta with a few macrotrichia in the middle. No appendix on third vein. Abdomen orange brown, darker apically, dark haired and with a median row of broad pale yellowish haired triangles on the first to sixth tergites. These triangles do not appear to be contiguous, and apparently are easily lost, as they are fully apparent only in a few of my specimens. Beneath the abdomen is reddish yellow, pale haired and greyish pollinose.

Holotype ♀ and 6 ♀ Paratypes, Boquete, Chiriqui Province,

Panama, May 7–10, 1939. 2 ♀ Paratypes, Boquete, March-April, 1941 (Mrs. T. B. Monniche).

This species agrees with a specimen in the Hine coll. (Chiriqui, A. H. Jennings) labelled "*T. simplex* Wlk., comp with type," but it does not agree very well with Walker's description (1850, Insecta Saund., Pt. 1, pp. 34–35, ♀, Colombia). Kröber in his catalogue (1934) places *simplex* as a doubtful synonym of *T.* (*Lophotabanus*) *bifloccus* Hine from Cuba. Hine's type comparisons have not proven infallible, and I prefer to redescribe the present species pending more definite information. The species seems closest to *haemagogus* Will., from which it may be distinguished by narrower frons, more slender antennae, and uncontiguous abdominal triangles.

Subgenus **Hybomitra** Enderlein

1922, Mitt. Mus. Berlin, X, 2, p. 347 (Type *H. solox* End. = *Tabanus rhombicus* O. S.); 1925, Op. cit., XI, 2, p. 364. Stone, 1938, U. S. Dept. Agric. Misc. Pub. No. 305, p. 36 (= *Tabanus* L.). Philip, 1941, Can. Ent., LXXIII, pp. 7–8.

Hybopelma Enderlein, 1922, Mitt. Mus. Berlin, X, 2, p. 351 (Type *T. quadripunctatus* F.); 1925, Op. cit., XI, 2, p. 355 (as *Hypopelma* lapsus), 409 (corrected to *Hybopelma*). Kröber, 1931, Zool. Anz., XCIV, p. 69.

Dasyphyrta Enderlein, 1922, Mitt. Mus. Berlin, X, 2, p. 351 (Type *T. maculipennis* Macq. = *T. quadripunctatus* var. *amabilis* Wlk.); 1925, Op. cit., XI, 2, p. 393. Kröber, 1932. Rev. Ent., II, p. 299.

Therioplectes Osten Sacken, 1876, Mem. Boston Soc. Nat. Hist., II, Pt. 4, No. 4, p. 425. Enderlein, 1925, Mitt. Mus. Berlin, XI, 2, p. 357 (in part). (Not *Therioplectes* Zeller 1842).

Sziladynus Enderlein, 1925, Zool. Anz., LXII, p. 287 (nom. nov. for *Therioplectes* End. and authors, nec. Zeller. Type *T. aterrimus* Meig.). Kröber, 1932, Rev. Ent., II, 2, p. 201. Bequaert, 1930, Harvard African Exp., p. 904. Borgmeier, 1933, Rev. Ent., III, p. 302. Kröber, 1934, Rev. Ent. IV, 3, p. 291 (? in part).

Poecilosoma Lutz, 1909, Inst. Oswaldo Cruz em Manguinhos, p. 29 (with *P. punctipenne* Macq., *P. quadripunctatum* Macq., *P. histrio* Wied., and *P. cinereum* Wied.); 1913, Brazil Medico, No. 45, p. 6, reprint (in key, no species); 1914, Mem. Inst. Osw. Cruz, VI, 3, p. 167 (reprinting of 1913 paper); 1914, Mem. Inst. Osw. Cruz, VI, 2, p. 72 (in list, with *quadripunctatum* Fab. and *punctipenne* Macq.). Bequaert, 1924, Psyche, XXXI, 1, p. 30, (Type *Tabanus quadripunctatus* Fab. 1805). Enderlein, 1925, Mitt. Mus. Berlin, XI, 2, p. 404 (= *Atylotus* O. S.). Not *Poecilosoma* Hubner 1816.

Poeciloderas Lutz, 1921, Bol. Inst. Osw. Cruz, I, p. 15. (with *quadripunctatus* (Lutz) but without indication of author or synonymy). Borgmeier, 1933, Rev. Ent., III, p. 299. (Type, *T. quadripunctatus* Fab.). Kröber, 1934, Rev. Ent., IV, 3, p. 297 (Subgenus of *Tabanus* with 10 Neotropical species).

Poecilochlamys Lutz, 1922, Zoologia Medica, Publ. Sep. da Folha Medica, Rio de Janeiro, pp. 9 and 11 (with a brief diagnosis, and in Key. No species); 1928, Est. Zool. Parasit. Venezolanas, p. 57 (in list with *P. quadripunctatus* Fab.).

Only one species of the present group occurs in Panama, the widespread *T. quadripunctatus* Fab. Philip (l. c.) has discussed the proper name for this group at some length, and his selection of *Hybomitra* End. seems to be the best way out of the tangle. While Philip treats the group as a full genus, there seem to me

to be too many intergrading forms, and I prefer to consider it merely a subgenus. Kröber (1929, 1931) has described a number of forms from Central and South America, but I have seen specimens of none of them.

Tabanus (Hybomitra) quadripunctatus Fabricius

(Fig. 8)

Tabanus quadripunctatus Fabricius, 1805, Syst. Antliat., p. 99 (no sex; South America). Wiedemann, 1821, Dipt. Exot., I, p. 77 (♀); 1828, Aussereurop. Zweifl. Ins. I, p. 151 (♀; Brazil). Walker, 1854, List Dipt. Brit. Mus. V., Suppl. 1, p. 219. Schiner, 1868, Reise Novara, Zool., II, Abt. 1, vol. B, Dipt. p. 86 (♂; ♀). Osten Sacken, 1878, Cat. North Amer. Dipt., p. 57. Williston, 1895, Kansas Univ. Quart., III, pt. 3, p. 195 (Rio de Janeiro); 1901, Biol. Centr.-Amer., Dipt., I, Suppl. pp. 257 and 259 (Mexico). Kertész, 1900, Cat. Taban., p. 67. Hunter, 1901, Trans. Amer. Ent. Soc., XXVII, p. 143. Aldrich, 1905, Cat. North American Dipt., p. 207. Ad. Lutz, 1907, Centralbl. Bakt. Parasit., Abt. 1, Orig., XLIV, p. 140. Kertész, 1908, Cat. Dipt., III, p. 272. Ad. Lutz and Neiva, 1909, Mem. Inst. Osw. Cruz, I, pp. 30 and 32 (States of Espirito Santo and Rio de Janeiro, Brazil). Hine, 1917, Trans. Amer. Ent. Soc., XLIII, p. 294 (♂; ♀; Costa Rica; Guatemala; Brazil, British Guiana). Surcouf, 1921, Gen. Insect., Taban., p. 81.

Tabanus (Therioplectes) quadripunctatus Osten Sacken, 1886, Biol. Centr.-Amer., Dipt., I, p. 48 (♂; ♀; Guatemala; Costa Rica).

Therioplectes quadripunctatus Speiser, 1904, Insekten-Börse, XXI, p. 148.

Poecilosoma quadripunctatum Lutz, 1909, Inst. Osw. Cruz em Manguinhos, p. 29. Ad. Lutz and Neiva, 1914, Mem. Inst. Osw. Cruz, VI, p. 72. Neiva and Penna, 1916, Mem. Inst. Osw. Cruz, VIII, p. 94. Ad. Lutz, Araujo and Fonseca, 1918, Mem. Inst. Osw. Cruz, X, pp. 167, 168 and 169 (Paraguay; Missiones, Argentina; States of Rio Grande do Sul, Sta. Catharina and Paraná, Brazil). Kröber, 1931, Zoolog. Anzeiger, XCIV, pp. 70 and 77, figs. 10–11 (♂; ♀; Costa Rica; Venezuela; Peru; Ecuador; Brazil; Bolivia; Uruguay; Mexico).

Poecilochlamys quadripunctatus Ad. Lutz, 1928, Est. Zool. Paras. Venezolanas, p. 57, Pl. IX, fig. 7 (♀; Venezuela).

Tabanus (Poeciloderas) quadripunctatus Kröber, 1934, Rev. de Entomologia, Rio de Janeiro, IV, p. 298. Galvao, 1935, Rev. Biol. Hyg. Sao Paulo, VI, pp. 121–125 (life history).

Hybopelma quadripunctatus Enderlein, 1922, Mitt. Zool. Mus. Berlin X, p. 351.

Hypopelma quadripunctatus Enderlein, 1925, Mitt. Zool. Mus. Berlin, XI, p. 355 (Missprint corrected on p. 409.).

Tabanus nigro-punctatus Bellardi, 1859, Saggio Ditter. Messicana, I, p. 67, Pl. II, fig. 8 (♀; Mexico; Cordova, Huastec).

Tabanus elegans Thunberg, 1827, Nova Acta Soc. Sci. Upsal., IX, p. 61, Pl. I, fig. 5 (no sex; no locality).

Tabanus punctipennis Macquart, 1838, Dipt. Exot., I, pt. 2, p. 185 (♀; Goyaz, Brazil). Walker, 1854, List Dipt. Brit. Mus., V, Suppl. 1, p. 218. Kertész, 1900, Cat. Taban., p. 66. Hunter, 1901, Trans. Amer. Ent. Soc., XXVII, p. 143. Kertész, 1908, Cat. Dipt., III, p. 271. Ad. Lutz and Neiva, 1909, Mem. Inst. Osw. Cruz, I, pt. 1, p. 32 (States of Rio de Janeiro and Minas Geraes, Brazil). Surcouf, 1921, Gen. Insect., Taban, p. 80. Hine, 1925, Occas. Pap. Mus. Zool. Univ. Michigan, No. 162, p. 32 (Costa Rica).

Poecilosoma punctipenne Ad. Lutz and Neiva, 1914, Mem. Inst. Osw. Cruz, VI, p. 72. Ad. Lutz, Araujo and Fonseca, 1918, Op. cit., X, pp. 168 and 169 (States of Sta. Catharina and Parana, Brazil).

Hypopelma punctipennis Enderlein, 1925, Mitt. Zool. Mus. Berlin, XI, p. 356.

Tabanus maculipennis Macquart, 1834, Hist. Nat. Ins. Dipt., I, p. 198 (♀; Brazil). Walker, 1854, List Dipt. Brit. Mus., V, Suppl. 1, p. 218. Kertész, 1900, Cat. Taban., p. 59; 1908, Cat. Dipt., III, p. 258. Ad. Lutz and Neiva, 1909, Mem. Inst. Osw. Cruz., I, pt. 1, p. 32 (State of Rio de Janeiro, Brazil). Surcouf, 1921, Gen. Insect., Taban., p. 74. Not of Wiedemann.

Bellardia maculipennis Rondani, 1863, Arch. per la Zool. Modena, III, pt. 1, p. 81.

Dasyphyrta maculipennis Enderlein, 1922, Mitt. Zool. Mus. Berlin, X, p. 344; 1925, Op. cit., XI, p. 393.
Tabanus amabilis Walker, 1848, List Dipt. Brit. Mus., I, p. 154.

There seems no reason why this species should not be placed with the North American forms with hairy eyes and vertexal tubercle. *T. reinwardtii* Wied. is in many respects the closest species though the vertexal tubercle is rather poorly developed. *T. quadripunctatus* F. shows considerable variation in this respect, however, and some specimens show a very weakly developed tubercle. The variety *amabilis* Wlk. with extensively white basal abdominal tergites, has not been so far taken in Panama.

Distribution: I have seen material from the states of Paraná, Matto Grosso, Sao Paulo, Rio de Janeiro, Bahia and Goyaz, Brasil, and from Peru, Brit. Guiana, Venezuela, Panama and Mexico. Kröber gives the range as Mexico to Uruguay.

Panama records: Summit, C. Z., Dec. 26, 1929 (Dunn); Moja Pollo, Chagres River region, Jan., May, June, July and November, 1940. The species is apparently not common in Panama.

Subgenus **Philipotabanus** subg. nov.

Phaeotabanus Kröber, 1930, Zool. Anz. LXXXVI, p. 273 (in part); 1934, Rev. Ent. IV, 3, p. 304 (in part).

This group is erected for a number of Central and South American species of *Tabanus* included by Kröber in the subgenus *Phaeotabanus* of Lutz, and corresponds in the main to Kröber's group *reticulatus* of that subgenus. *Tabanus ebrius* Osten Sacken, 1886, is selected as sub-genotype. The type of *Phaeotabanus* Lutz is *Tabanus litigiosus* Walker, 1850, selected by Bequaert (1924); and it and a number of related forms differ sufficiently from *Tabanus sens. lat.* to require full generic standing in my opinion. *P. litigiosus* Wlk., *semiflavus* Kröb. and *limpidapex* Wied. have the subepaulet bare, costa, subcosta and first vein with macrotrichia above, and the labella bear shiny chitinized plates. *Tabanus ebrius* O. S., *fascipennis* Macq., *reticulatus* Kröb., *tenuifasciatus* Kröb. and some other related forms have macrotrichia upon the subepaulet and the labella entirely fleshy.

Kröber seems to have placed a number of not very closely related forms in *Phaeotabanus*, mostly on the basis of their pictured wings and apparent lack of other distinguishing features. Thus the bare subepaulet, fleshy labella and setose

fifth vein of *T. fuscipennis* Wied. set it apart, while the broad frons, curiously spotted wings and setose subepaulet of *P. multiguttatus* Kröb. and probably also *P. austeni* Kröb., which I have not seen, would place them very close to *T. venustus* O. S. from North America. I have not sufficient material to do more than point out the fact that *Phaeotabanus* Kröber is a very heterogeneous group, and to segregate the present complex, as it includes all the Panamanian species.

Philipotabanus may be defined as follows:

Small to medium sized flies, 7 to 15 mm. long. Eyes bare, unicolorous dull greenish in life. Frons narrow to very narrow; frontal callus club shaped or ridge like, vertexal tubercle absent or represented by a small bare spot. Subcallus and face normal, not bare or swollen. Antennae *Tabanus*-like, rather slender, without unusual features. Palpi rather long and very slender, proboscis not or barely equalling head height, the labella fleshy, at least half length of proboscis. Thorax, abdomen and legs brown or black, the last generally unicolorous. Wings with subepaulet bearing macrotrichia, as do the costa, subcosta, and first vein above, and the costa and subcosta beneath. All cells but the anal open; no appendix on third vein. The wings are always marked with brown, in a pattern which has a tendency to leave the areas around the cross veins hyaline, except in *fascipennis* Macq. and allied species.

The male of only one species, *ebrius*, appears to have been taken, and a description of it will be found under that species.

The species of this group are very puzzling. Either there are many rather restricted species, or a few very variable forms. I have, after considerable hesitation, decided to consider the various forms as distinct species, as I am unable to group them satisfactorily with the material at hand. Use of any single character for grouping results in a group heterogeneous for practically all other characters, i. e., there seems to be little or no correlation between the various available characters. Furthermore, there appears to be very little intermediacy, each form being rather clear cut, so that the lumping of all the forms under one species, as Hine (1925) did, only begs the question. With the accumulation of further material from a long series of localities, it may well be possible to define a few species, each with a number of local races. All the specimens I have seen are much alike in structure, differing mainly in size, intensity of body coloring, and development or reduction of the basically similar wing pattern. I have before me 6 apparently distinct forms from Panama, as well as 2 others from other localities. Of these, I have been able to assign names to 4, but not with any degree of certainty. Lacking Mexican material,

I have hesitated to use either *caliginosus* Bell. or *alteripennis* Wlk. for Panama material. Kröber did not recognize any of the earlier names in this group, and redescribed *ebrius* O. S., so it is possible that some of his many names may refer to those species.

In Panama the members of the group are not uncommon during the earlier part of the rainy season in heavily forested areas. Occasionally they become annoyingly abundant, and will bite man readily, though the bite is not very painful and leaves little after effect.

The forms occurring in Panama, together with such other material as is before me, may be separated by the following key, used in conjunction with the accompanying figures.

KEY TO SPECIES OF SUBGENUS PHILIPOTABANUS

1. Whole wing black, except apex, anal cell, and median area at apices of basal cells extending to the costa (Venezuela)..... **fascipennis**
   Wing otherwise marked, but areas around the cross-veins always hyaline. (See figures).....2
2. Wing pattern of dark streaks and spots. Abdomen orange brown to nearly black. Scutellum dark brown, thoracic stripes prominent. 12–14 mm..... **ebrius**
   Without the above combination of characters.....3
3. Abdomen mainly yellowish or light brown.....4
   Abdomen mainly blackish, or dark brown.....8
4. Legs blackish. Abdomen with a small middorsal white triangle on the fourth tergite or unicolorous. Apex of wing along costa distinctly dusky. 7–9 mm..... **magnificus**
   At least the last two pairs of legs yellowish or reddish. Over 10 mm.....5
5. Fore legs darker than the others. Wing pattern clear cut and distinct. Antennal tooth rather short. 11 mm. (Bolivia)..... **reticulatus**
   All legs light. Wing pattern rather faded. Antennal tooth well marked.....6
6. Abdomen with small white mid-dorsal triangles on tergites 2 to 4. Dark area of wing extending into base of second submarginal cell. **pterographicus**
   Abdomen without light triangles. Second submarginal cell all hyaline, rarely with a very small spot near the base.....7
7. Small species, 11–12 mm..... **chrysothrix**
   Large species, 15–16 mm..... **elviae**
8. No dark spot at base of second submarginal cell. Third antennal segment unusually broad. Abdomen dark reddish brown. (Br. Honduras)..... **kompi**
   A dark spot at base of second submarginal cell which is broadly connected with cross-band..... **medius**

Tabanus (**Philipotabanus**) **ebrius** Osten Sacken

(Fig. 14)

Tabanus ebrius Osten Sacken, 1886, Biol. Centr.-Amer., Dipt. X, p. 49, Pl. I, fig. 8 (♀; Irazu, Costa Rica; Volcan de Chiriqui, Panama). Williston, 1901, Biol. Centr.-Amer. Dipt., I, Suppl., p. 259 (=*caliginosus* Bell.). Kertész, 1900, Cat. Taban., p. 48. Surcouf, 1921, Gen. Insect., Taban., p. 63. Hine, 1925, Occ. Pap. Mus. Zool. Univ. Michigan, No. 162, p. 30 (=*caliginosus* Bell.; Boquete, Panama).

Tabanus erebus Hine (nec. *T. erebus* Osten Sacken) 1917, Trans. Am. Ent. Soc., XLIII, p. 295 (confusion of *erebus* and *ebrius*).

Tabanus (*Phaeotabanus*) *ebrius* Kröber, 1930, Zool. Anz., LXXXVI, p. 277; 1934, Rev. Ent. IV, 3, p. 305.

Tabanus (*Phaeotabanus*) *ocelligerus* Kröber, 1930, Zool. Anz., LXXXVI, pp. 296–297, figs. 18, 18a (♀; Costa Rica); 1934, Rev. Ent., IV, 3, p. 305.

This species is distinguishable readily from others of the group in Panama by the distinctive wing pattern and prominently striped thorax. A male before me may be designated as Allotype.

Eyes contiguous. The large facets much larger than the small and sharply demarcated from them. The area of large facets is definitely pubescent, the small facets bare, and the former occupies about ⅔ of the total eye area. A very small tubercle is present between the eyes at vertex. Antennae missing. Palpi short, rather inflated, curved. Coloration as in the female, the thorax and abdomen with longer hairs, and the abdomen pointed.

Allotype ♂, Boquete, Chiriqui Prov. Panama, May–June, 1940 (Mrs. T. B. Monniche coll.). Certain specimens have the abdomen almost black, and I had at first considered them to be a distinct form, but more material has shown a complete intergradation of characters.

Distribution: Costa Rica and Panama, at higher elevations.

Panama records: Volcan de Chiriqui, 2000–3000 ft. (Champion; Osten Sacken's Types). Boquete, May 15, 1923 (Gaige coll., in Hine coll.), labelled "*ebrius* comp. with type." Boquete, Chiriqui Prov., May 8–9, 1939. (Many females); May–June, 1940 (Mrs. T. B. Monniche); June, 1941 (Mrs. T. B. Monniche). Cerro Punta, Chiriqui Prov., 6000 ft., Feb.–Mar., 1940 (T. T. Howard coll.).

Tabanus (Philipotabanus) magnificus Krōber

(Fig. 13)

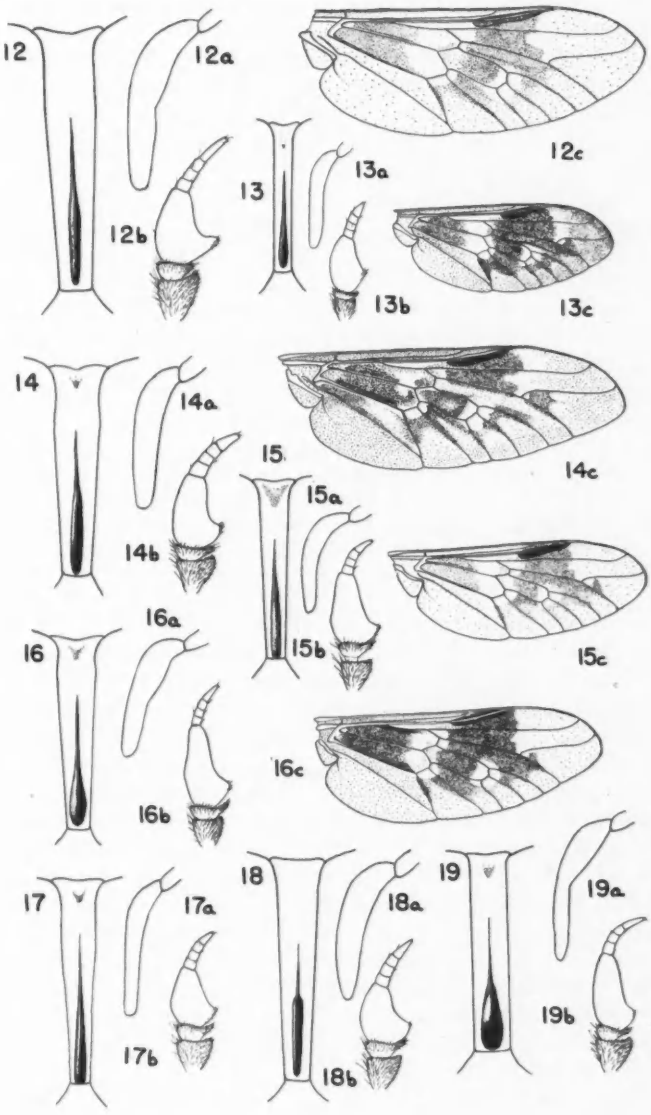
Tabanus (Phaeotabanus) formosus Krōber, 1930, Zool. Anz., LXXXVI, p. 299, figs. 21, 21a. (♀; Ecuador) (not *T. formosus* Walk. 1848). Bequaert, 1940, Rev. Ent., XI, 1–2, p. 291.

Tabanus (Phaeotabanus) magnificus Krōber, 1934, Rev. Ent., IV, 3, p. 305 (Ecuador, Costa Rica, Colombia).

This is very much the smallest species of the group in Panama, being easily mistaken at first glance for a species of *Chrysops*. It is a persistent biter in forested regions, appearing to prefer the ears and nose, like *Chrysops*. The eyes are bronzy in life, without bands.

EXPLANATION OF FIGURES IN PLATE II

Figs. 12, 12a, 12b, 12c—*T. (Philipotabanus) elviae* n. sp. Paratype. 13, 13a, 13b, 13c—*T. (P.) magnificus* Krōb. 14, 14a, 14b, 14c—*T. (P.) ebrius* O. S. 15, 15a, 15b, 15c—*T. (P.) pterographicus* n. sp. Paratype. 16, 16a, 16b, 16c—*T. (P.) medius* Krōb. 17, 17a, 17b—*T. (P.) chrysothrix* n. sp. Paratype. 18, 18a, 18b—*T. (P.) kompi* n. sp. Paratype. 19, 19a, 19b—*T. (P.) fascipennis* Macq.


12
12a
12b
12c
13
13a
13b
13c
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14a
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15b
15c
16
16a
16b
16c
17
17a
17b
18
18a
18b
19
19a
19b

Distribution: Kröber records it from Costa Rica, Colombia, Ecuador and Santo Domingo. I have seen specimens in the Hine Collection and U. S. N. M. from Higuito, Costa Rica (Schild), and Livingston, Guatemala, May 6 (Barber and Schwartz). I have also specimens from Guayaquil, Ecuador, and Surotka, C. R., May, 1924 (J. C. Bradley). As Bequaert has noted (l. c. 1940) the species probably does not occur in the West Indies.

Panama records: El Valle, Coclé Prov., May 20, 1939. New San Juan, Chagres River region, June 28, 1939. Cerro Campana, Panama Prov., July 2 and 11, 1939. Police Station, Rio Pequeni, C. Z., May 11 and Aug. 21, 1940. Cerro Azul, Panama Prov., May 17, 1941. Changuinola Dist., Bocas del Toro Prov., May 19, 1924 (F. R. Swift coll.). Boqueron River, May, 1907 (Busck coll.). Cano Saddle, Gatun, C. Z., May-June, 1923 (Shannon coll.). Mohinga Swamp, Gatun, C. Z., Aug. 26, 1940.

Tabanus (Philipotabanus) medius Kröber

(Fig. 16)

Tabanus (*Phaeotabanus*) *intermedius* Kröber, 1930, Zool. Anz., XC, p. 81 (♀; Suiza de Turrialba, Costa Rica) (not *T. intermedius* Walk., 1848; not *T. intermedius* Egger 1859.).

Tabanus (*Phaeotabanus*) *medius* Kröber, 1934, Rev. Ent., IV, 3, p. 305.

Rather extensive material from Panama before me seems to agree quite closely with Kröber's description. It differs from all the other Panama forms except certain dark specimens of *ebrius* in the nearly black abdomen, and from that species by different antennae and different wings. This species and *magnificus* Kröb. seem about equally abundant, but although both occur together in a number of localities, one is always much more abundant. Thus at El Valle and Cerro Azul both occur, but *magnificus* is dominant, while in the Chagres River region *medius* is abundant, *magnificus* rare. *Magnificus* is also abundant on the Rio Pequeni and on Cerro Campana, where *medius* has not been taken, while *medius* is common on the Cerro Macaracas and at Camp Pital, in Chiriqui, where *magnificus* has not been taken. Neither of these species seems to have been taken in the Volcan area. The other two Panama forms are known only from a few specimens, all taken in company with one or both of the above.

Panama records: Moja Pollo, Chagres River region, May 15 to Sept. 1, 1940. New San Juan, Chagres River region, June

28, 1939. Cerro Macaracas, Veraguas Prov., July 15, 1940 (E. R. and M. T. Dunn coll.). Camp Pital, Chiriqui Prov., July 11, 1929 (L. H. Dunn). El Valle, Coclé Prov., June 18, 1939. Quipo, R. P., July, 1922, (J. P. Chapin). Barro Colorado Is., C. Z., June 29, 1923 (R. C. Shannon). Cerro Azul, Panama Prov., May 17, 1941. Cabima, R. P., May 25, 1911 (Busck).

Tabanus (Philipotabanus) pterographicus sp. nov.

(Fig. 15)

Female.—Length 10 mm., of wing, 10 mm.

Eyes bare, bronzy in life. Frons narrow, about 9½ times as high as basal width, widest at vertex, pale yellowish brown. Frontal callus linear, brown, extending nearly to vertex, where there is a small, bare, slightly raised and discolored area. Subcallus, fronto-clypeus and genae pale yellowish grey pollinose, the last with sparse pale brownish hairs. Antennae as figured, orange yellow, the annulate portion darker, and with dark hairs on the first two and angle of the third segments. Palpi as figured, pale brown, black haired. Proboscis brown, the labella about ⅔ of total length, fleshy.

Mesonotum light brown, stripes nearly obsolete, dark haired; scutellum concolorous, lighter at apex, white haired. Pleura and sternum paler, sparsely brown and whitish haired. Legs yellowish brown, the fore pair darker, all black haired. Wings as figured. Abdomen dirty yellowish brown, dark haired, darker at apex, and with small but well marked triangles of white hairs on hind margins of first to fourth tergites. Venter lighter, sternites obscurely pale margined.

Holotype ♀, Moja Pollo, Chagres River region, Jan. 1, 1940. 1 ♀ Paratype, same locality, Dec. 6, 1939. To be deposited in the M. C. Z., Harvard Univ., Cambridge, Mass.

This species may be distinguished from *reticulatus* Kröb. by the very different antennae, narrower convergent frons, and lack of apical wing infuscation. From *medius* Kröb. it differs in much lighter color, narrower frons, smaller size and reduced wing picture. The season of flight also appears to be quite different though with but two specimens this cannot be given much weight. *Pallidetinctus* Kröb., described from Panama, I have not been able to recognize in my material. It may have been based on specimens of either this or the next species, but if so, the description leaves very much to be desired.

Tabanus (Philipotabanus) chrysothrix sp. nov.

(Fig. 17)

Female.—Length 10–10.5 mm., of wing, 10 mm.

Differs from the preceding species only in the following respects. Scutellum and abdomen largely clothed with golden hairs, without

contrasting tergal triangles of white hairs. Body color more rufous. Legs largely orange haired. Wing markings further reduced, lacking the extension in to the second submarginal cell.

Holotype ♀ Police Station, Rio Pequeni, Panama, May 11, 1940. 3 ♀ Paratypes, Cabima, Panama, May 19 and 21, 1911 (August Busck coll.). Holotype to be deposited in the M. C. Z., Harvard Univ., Cambridge, Mass. Paratypes in the U. S. N. M.

This form, while agreeing with *reticulatus* Kröb. and *pterographicus* sp. nov. in size and general coloration, approaches the two following species in the wing pattern.

Tabanus (Philipotabanus) elviae sp. nov.

(Fig. 12)

Female.—Length 14–15 mm., of wing, 13 mm.

Eyes bare, probably unicolorous bronzy in life. Frons orange brown pollinose, about 8½ times basal width, wider at vertex. Frontal callus linear, not reaching base of frons. Vertex with a slightly discolored area. Subcallus, fronto-clypeus and genea concolorous, orange brown, the last with a sparse orange beard. Antennae as figured, orange throughout, the first two segments and angle of the third with reddish brown hairs. Palpi as figured, pale orange brown with black hairs.

Mesonotum orange brown, stripes obsolescent; scutellum orange with golden hairs. Pleura and sternum paler, mostly orange haired. Legs reddish, mostly golden haired, the fore pair dark haired. Wings as figured. Abdomen orange brown, reddish brown haired, the hind margins of the tergites paler and with golden hairs, forming indistinct triangles in the mid-line.

Holotype ♀ and 4 ♀ Paratypes, Buena Vista, Chiriqui Volcano, 1000 ft., Panama, March (J. D. Smith coll.). To be deposited in the M. C. Z., Harvard Univ., Cambridge, Mass.

The large size, reduced wing pattern and golden or coppery body pubescence should serve to distinguish this form. It is in many respects a large edition of *chrysothrix*, but the antennae are quite different.

Tabanus (Philipotabanus) kompi sp. nov.

(Fig. 18)

Female.—Length 11–13 mm., of wing, 10.5–12 mm.

Eyes bare, probably bronzy in life. Frons narrow, about 8 times as high as wide, yellowish grey pollinose. Frontal callus linear, chestnut brown, hardly a vestige of a vertexal bare spot. Subcallus, fronto-clypeus and genae brownish grey, the last with a sparse pale brown beard. Antennae as figured, orange, the annulate portion darker, the first two segments and angle of third dark haired. Palpi as figured, pale brown, black haired.

Mesonotum dark brown, dark haired, the stripes obsolescent. Scutellum concolorous, its posterior margin sparsely silver haired. Pleura and sternum grey and brown haired. Legs yellowish brown, the fore pair darker, all with mostly dark hair. Wings as figured. Abdomen cinnamon brown, sometimes lighter, especially on the first few tergites, dark brown to black haired. The third and fourth tergites, sometimes also the second, bear silvery haired median triangles, that on the fourth much the largest. Venter paler, sparsely pale haired, especially the light hind margins of the sternites.

Holotype ♀ and 14 ♀ Paratypes from Stann Creek, British Honduras, March 19, 1940 (W. H. W. Komp coll.); 8 ♀ Paratypes, Silk Grass, British Honduras, March 17, 1940 (Komp. coll.). Holotype and 3 Paratypes to be despoited in the M. C. Z., Harvard Univ., Cambridge, Mass., other Paratypes in the U. S. N. M. and author's collection.

I have also seen three specimens from Tela, Rep. of Honduras (Bates coll.) which I place provisionally here. The wing pattern is the same, but the frons is wider and the whole insect much paler, quite yellowish. They are much like ***chrysothrix***, but the frons is broader, wing darker, the hyaline area about the end of the discal cell smaller and more circumscribed, and the antennal tooth much longer. The present species is closest to ***elviae*** in wing pattern, but approaches ***medius*** Kröber in body color.

Tabanus (Philipotabanus) reticulatus Kröber

Tabanus (Phaeotabanus) reticulatus Kröber, 1930, Zool. Anz., LXXXVI, pp. 298–299, figs. 20, 20a (♀; Peru, Pichis Weg, Pto Yessup); 1934, Rev. Ent., IV, 3, p. 305.

Two from Prov. Sara, Bolivia (Steinbach) are before me, which agree fairly well with the description. They differ from the other species here considered in the more open hyaline spot at the apex of the discal cell, short antennal tooth, and rather broader more parallel sided frons. The apical infuscation of the wing is much fainter than that shown in Kröber's figure.

Tabanus (Philipotabanus) pallidetinctus Kröber

Tabanus (Phaeotabanus) pallidetinctus Kröber, 1930, Zool. Anz., LXXXVI, pp. 297–298, figs. 19, 19a (♀; Panama); 1934, Rev. Ent., IV, 3, p. 305.

I have been unable to recognize this species in my material. The entirely dark costa is unusual, and precludes its identification with either ***pterographicus*** or ***chrysothrix***, to which it seems most closely related. It is quite distinct from anything I have seen from the Chiriqui region.

Panama records: Chiriquicito, March (Kröber).

Tabanus (Philipotabanus) fascipennis Macquart

(Fig. 19)

Tabanus fascipennis Macquart, 1845, Dipt. Exot., Suppl. 1, p. 35, Pl. 4, fig. 1. (♀; New Grenada).

Tabanus (*Phaeotabanus*) *fascipennis* Kröber, 1930, Zool. Anz., LXXXVI, p. 278, figs. 1, 1a. (Bogota, Venezuela); 1934, Rev. Ent., IV, 3, p. 305.

A series of specimens in the U. S. N. M. from Choroni, Venezuela (Lichy) enables me to supplement Kröber's description in a few points. The frons is rather narrower, about 5½ times as high as basal width. The abdomen is wholly black, with a small white haired triangle on only the fourth tergite in my specimens. The peculiar angle of the palpi shown in Kröber's figure is present also in my material, but the antennae are a little broader than shown. The species may occur in Eastern Panama, where very little collecting has been done.

RESUME OF THE TABANIDAE OF PANAMA

In previous papers (1939–1942) the genera occurring in Panama have been discussed in some detail, and the various species figured. It remains only to give some brief notes on the Tabanid fauna of the Republic as a whole, its classification and relation to the fauna of other areas, a few remarks on the environment, and a check list of the known forms.

No work of this nature is wholly the product of its author, and though the sources of the author's ideas can be partly gleaned from the literature cited, by far the most important contributions are those resulting from conversations and correspondence with other enthusiasts. In the present case, much of whatever is useful or original in this series of papers has been the result of such discussions with Dr. Joseph Bequaert, Dr. C. B. Philip, Dr. L. L. Pechuman, Mr. R. C. Shannon and Dr. Alan Stone. To these and many others I am also indebted for the loan and gift of much valuable material, without which this study would hardly have been possible.

I have also been unusually fortunate in having been able to study a large proportion of the Central American Tabanidae available in American collections, but I have been naturally handicapped by the inacessibility of the types of European authors. The Panama material in the following collections has been examined: U. S. National Museum; American Museum of Natural History; Museum of Comparative Zoology, Harvard University; J. S. Hine collection, Ohio State University; and

the collection of Dr. Joseph Bequaert at the Harvard Medical School. In addition, the collections made by Major L. H. Dunn and preserved at the Gorgas Memorial Laboratory in Panama have been constantly available. My own field work in Panama, extending over three years, has yielded an estimated 20,000 additional specimens.

The climate and physiography of the Republic is quite diversified, but little or no detailed work on the subject appears to be available. Most of the existing temperature and rainfall records refer to the area adjacent to the Panama Canal, but are to a certain extent characteristic of the whole area. The year is divided into two seasons, "wet" and "dry." The wet season begins generally sometime in May and continues usually until the latter part of December. On the Atlantic side of the isthmus there is some rain more or less throughout the year, the "dry" season being only relatively so, but on the Pacific side, from the Canal Zone west at least to Costa Rica, there may be no rain at all from December to the end of May. East of the Canal Zone the conditions appear to be to some extent reversed, the Atlantic coast becoming progressively dryer towards the Colombian border, while the Pacific coast becomes wetter. Total annual rainfall ranges from 100, or often more, inches on the Atlantic side, to 70 inches at Panama City. Farther westward along the Pacific coast, the rainfall is probably even less.

Physically the country is encroached upon at either end by the Costa Rican and Colombian mountain systems. In Chiriqui Province the country is dominated by the Volcan de Chiriqui, an extinct volcanic peak close to 12,000 ft. high, which forms the eastern end of the chain of Costa Rican volcanoes. In Darien Province a spur of the Colombian Andes enters the country, elevations of somewhat over 8000 feet being reached. Between these two systems the country is traversed lengthwise by a sort of backbone range of hills, lowest at the Canal Zone, generally higher towards the Costa Rican and Colombian borders, but seldom exceeding 4,000 or 5,000 feet. This central ridge lies for the most part nearer the Atlantic or Caribbean coast, so that the Pacific side has a wider strip of relatively level land.

A great deal of the Republic is still covered with heavy forest, but about the Canal Zone and along the Pacific coast west of the Canal much of it has been cleared at one time or another

for agriculture, and then allowed to grow up again into an utterly impenetrable second growth. True llanos, rolling grass-covered plains, are increasingly evident westward of the canal, and some of these at least are a natural feature of the country, though it seems very probable that their original area has been much increased by the annual fires which are set by the inhabitants to improve the grazing, as this area is largely a cattle section.

Swamps, both fresh and tidal, are found along both coasts, but other than the artificial Gatun and Madden Lakes, there seem to be but few large bodies of fresh water. The tidal mangrove swamps form one of the most interesting habitats, and quite a number of Tabanids seem to be wholly or largely confined to them. Altitude, here as elsewhere, has an important influence on vegetation, and the tops of even relatively low hills, 2500–3000 feet, are kept moist and green throughout the dry season by often almost constant cloud caps. The so-called fog forest developing on these hills yields very interesting collecting, and quite a number of Tabanids seem confined to these areas.

Since most Tabanids are haematophagous, Bequaert (1940, p. 264) has suggested that the paucity of large mammals in the Antilles may well be the cause of the depauperate Tabanid fauna found here. Panama, being continental, has a considerable number of large native mammals, in addition to a good population of horses and cattle. Two genera of deer, *Odocoileus* and *Mazama*, tapir, (*Tapirella bairdi*), two genera of peccary (*Pecari* and *Tayassu*), the capybara (*Hydrochoerus*), puma, jaguar and ocelot are all large enough to be attractive to Tabanids, while there are a host of smaller mammals as well as several large reptiles such as the iguana lizard, various species of freshwater and marine turtles, and large snakes. Observations of the feeding habits of Tabanids on wild animals are naturally not often made, but the capture of a specimen of *Fidena isthmiae* Fairch. feeding on a large snake (*Epicrates* or *Constrictor* sp.) by Mr. W. H. W. Komp is worthy of note. Tabanids have previously been recorded as feeding on both crocodiles and sea turtles. (Bequaert, 1940).

The relationships of the Panama Tabanid fauna to that of neighboring areas must be largely a matter of guesswork, since little intensive collecting has been done anywhere in Tropical America. My own collecting in Panama has been largely confined to the central part of the Isthmus, so that many species

coming into the country from Costa Rica and Colombia have undoubtedly been missed. Nevertheless, the information available tends to show that the Central American elements in the fauna are slightly in the ascendency. Thus of the 59 Panama species known to occur in other areas also, 12 or about 20% are known from South America but not from Central America, 17 or about 30% are known from Central America but not from South America, while 30 or about 50% are known from both South and Central America. The 30 species known at present only from Panama can only tentatively be classed as true endemics, since many or most of them may be found in neighboring areas when more collecting has been done.

A comparison of the total number of species known from Panama with similar lists from other areas, indicates that the fauna is a relatively rich one. The land surface of the Republic is estimated to be between 31,500 and 33,800 square miles (Encyclopaedia Brittanica, 11th Ed.), and 89 species are known to occur within its boundaries. Bequaert (1940a) gives the following figures for the Antilles: Antilles as a whole, 95,000 sq. mi. and 42 species; Cuba, 44,000 sq. mi. and 12 species; Hispaniola, 28,250 sq. mi. and 17 species. The Republic of Honduras, which has been little explored, contains 46,000 sq. mi. and Bequaert lists (1940a) 22 species as occurring there. The same author lists (1940b) 23 species from Trinidad, with an area of only 1,734 sq. mi. In North America, where the Tabanids have been much more extensively studied and collected, Johnson lists (1925) 85 species for the 6 New England states, with an area of 64,800 sq. mi., and my own list of Florida species (1937), to which several species have been subsequently added, comprises 66 species from an area of about 59,000 sq. mi.

CLASSIFICATION: HISTORICAL

The classification of the Tabanidae, in spite of a number of attempts to place it on a sound basis, still remains in a very chaotic condition, and there seems no immediate prospect of improvement. The characters hitherto used to group the species into genera and higher categories seem for the most part quite inadequate, and a complete re-study of the whole family in a search for more and better characters will be necessary before any real progress can be made.

Three main systems of classification of the family exist. Of these the oldest divides the family into two subfamilies,

Pangoniinae and *Tabaninae*, each of which is divided into a variable number of genera. The most recent attempt to apply this system to the world fauna is that of Surcouf in the Genera Insectorum (1921). Here the *Tabaninae* comprise 18 genera of which 9 are monotypic, while the Genus *Tabanus* with three subgenera contains 1140 species. In the *Pangoniinae*, Surcouf recognizes 42 genera, of which 16 are monotypic, while *Chrysops* and *Pangonius*, the two largest genera, are listed as containing 200 and 109 species respectively. While Surcouf recognizes a number of the groups proposed by Lutz (1909) in the *Pangoniinae*, he does not recognize Lutz' divisions of the *Tabaninae*.

The first important departure from the old system was proposed by Adolfo Lutz in a series of papers (1909 et seq.) dealing with the Brazilian fauna. He replaced the old subfamilies *Pangoniinae* and *Tabaninae* by the names *Opisthacanthae* and *Opisthanoplae*, and divided the former into the subfamilies *Pangoniinae*, *Silviinae* and *Chrysopinae*, and the latter into the subfamilies *Tabaninae*, *Lepiselaginae* and *Diachlorinae*. The *Tabaninae* was further divided into two series on the basis of the presence or absence of a long tooth on the third antennal segment, the *Schistocerae* having a long tooth, the *Haplocerae* lacking it. The two series were then divided into genera largely on the basis of eye coloration, the *Schistocerae* containing 9 genera, of which 6 were new, and the *Haplocerae* consisting of 9 roughly parallel genera, of which 8 were new. Lutz' system had a number of features to recommend it, and many of his groups seem to express natural relations, but the system was founded on a rich but limited fauna, while Lutz was often unfortunate in his choice of distinguishing characters. Many of his names were first published in lists of species, while others appeared in keys without species, and in no case were genotypes specifically selected. This led to considerable confusion and misunderstanding and the loss of several of Lutz' names.

In 1922 and 1925 G. Enderlein published what was intended to be a world-wide revision of the family. Following Lutz in the use of *Opisthacanthae* and *Opisthanoplae* Enderlein goes much further, dividing the family into 10 subfamilies, 19 tribes, and 170 genera. His classification is rather arbitrary, in many cases separating quite closely allied forms. Very few new characters are used, dependence being placed mainly on the various possible groupings of already known characters. The

system has been widely criticized (Bequaert 1924, Kröber, 1932, Stone, 1938); but Enderlein has selected genotypes throughout, so that in many cases his groups are recognizable. He was, however, not always careful, and in a number of cases genotypes had previously been selected by others. A number of his supposedly new species, upon which he based new genera, have also proven to be synonyms; and in other cases his genotypes and genera were based on misdetermined material. In one case at least, he placed the same species in three different genera. Enderlein recognized only a few of Lutz' genera, sinking the majority of them more or less at random.

Beginning about 1925, Otto Kröber published a long series of papers dealing exhaustively with the family, the Neotropical fauna alone occupying about 40 titles. In two papers (1932 and 1934) his system of classification, as far as the Neotropical region is concerned, is set forth. For the most part he follows Enderlein with minor changes, recognizing many of Lutz' generic names. He used 83 generic and subgeneric names for the Neotropical fauna. While Kröber's work is a great improvement over that of Enderlein and Lutz, he also has failed to discover any new characters which can be used for classification, and his system remains very largely artificial.

Dr. J. Bequaert (1930) in discussing the African *Tabanidae* recognizes 3 subfamilies, the *Coenomyinae*, *Pangoniinae* and *Tabaninae*, and divides the second of these into 3 tribes, the *Pangoniini*, *Chrysopini* and *Scepsidini*, and the *Tabaninae* into the *Tabanini* and *Haematopotini*. This treatment is strongly contrasted with that of Enderlein and Kröber, and has all the advantages of great simplicity. I feel, however, that the very diverse elements to be found, especially in the *Pangoniini* and *Tabanini* of Bequaert are susceptible of more detailed analysis. I realize, however, the danger, especially when dealing with a limited fauna, of too fine a division, and feel that in dealing with the Panama species a middle course is advisable.

Dr. C. B. Philip has recently published (1941) a very stimulating scheme of classification of the Nearctic *Tabanidae*, with most of which I find myself in hearty agreement. He divides the Nearctic forms into 3 subfamilies, 9 tribes, and 29 genera. Of these, 2 subfamilies, 8 tribes, and 11 genera also occur in Panama. Philip separates the genus *Diachlorus* from *Stenotabanus*, placing them in separate tribes; but I believe this to be

unnecessary, and include both in the *Diachlorini*. I also believe *Chlorotabanus* to be rather closely related to the other *Dichelacerini* through such forms as *Cryptotylus*, and not worthy of tribal treatment.

Failing any entirely satisfactory existing system, it has been found quite impossible to come to any final decision as to the correct placement of a number of the Panama forms. While I have had the opportunity of examining a great deal of Neotropical material, as well as a large majority of the described Nearctic species, and a fair number of Old World forms, still I am very far from being in a position to erect any comprehensive scheme of classification for the whole family. The arrangement here adopted for the Panama species is therefore entirely tentative, and the key to supra-specific categories will probably not hold for extra-limital forms. I have used in the key a number of characters hitherto very seldom noticed in the family, but which seem to me in many cases to indicate relationships much better than most of the characters previously employed.

CLASSIFICATION OF THE SPECIES OCCURRING IN PANAMA

I have reverted to the terms *Pangoniinae* and *Tabaninae* for the main divisions of the family as it is represented in Panama, as the numerous subfamilies of Enderlein and Kröber do not seem to me sufficiently definable, nor do they appear to be at all of equal rank. In the *Pangoniinae* I recognize only two tribes as occurring in Panama, the *Chrysopini*, corresponding to the subfamily *Silviinae* of Kröber's catalogue (1934) and the *Pangoniini*, which includes all three tribes of the *Pangoniinae* of Kröber's catalogue. Among the *Tabaninae*, I recognize 5 tribes as follows: the *Lepiselagini*, corresponding to Kröber's subfamily of the same name; the *Diachlorini*, corresponding in part to Kröber's *Diachlorinae* and *Stenotabaninae;* the *Bolbodimyini* of Philip; the *Dichelacerini*, which includes part of Kröber's *Psalidini* and most of his *Dichelacerini* plus *Chlorotabanus* of his *Tabanini;* and the *Tabanini*, which includes part of Kröber's *Bellardiini*, *Dichelacerini* and *Tabanini*. I give below a key to the tribes and a key to the genera occurring in Panama, with the reservation that they will not always work in dealing with extra-limital forms.

KEY TO TRIBES

1. Hind tibiae with apical spurs. Subcosta always bare both above and below. Labella always with shiny sclerotized plates.....2. **Pangoniinae**
   Hind tibiae without apical spurs. Subcosta generally hairy, at least with some hairs beneath.....3. **Tabaninae**
2. First two antennal segments often together as long or longer than third. Third antennal segment of a long basal part and 4 terminal annuli. Proboscis seldom exceeding headheight.....**Chrysopini**
   First two antennal segments seldom together equalling half the length of the third. Third antennal segment of 7 or 8 distinct subequal annuli. Proboscis often much exceeding head height.....**Pangoniini**
3. Subepaulet bare, rarely with a few scattered bristles.....4
   Subepaulet clothed with macrotrichia like those on the costa.....**Tabanini**
4. Third antennal segment with a long dorsal tooth or spine, or the labella shiny and sclerotized and the whole insect greenish in life....**Dichelacerini**
   Third antennal segment never with a long dorsal spine, generally weakly angulate or subcylindrical, or labella wholly membranous.....5
5. Palpi shiny, flattened, the outer surface convex, the inner concave, those of the male nearly as large as in female, greatly inflated. All tibiae inflated. Wings black on basal half to two-thirds, hyaline apically. Largely black and shiny species with shiny facial callosities. Labella wholly membranous.....**Lepiselagini**
   Palpi pollinose, slender or inflated, but not flattened, those of the male small.....6
6. Subcallus and first antennal segment greatly inflated, shiny; face normal, pollinose. Body and wings largely black. Labella with small shiny plates at base. Palpi slender, pollinose. Upper branch of third vein turned abruptly forward.....**Bolbodimyini**
   Subcallus and first antennal segment not inflated. Upper branch of third vein normal. Wings never predominantly black.....**Diachlorini**

KEY TO GENERA

1. Hind tibiae with apical spurs. Subepaulet without macrotrichia, subcosta bare both above and below. Labella always with shiny sclerotized plates, 2. **(Pangoniinae)**
   Hind tibiae without apical spurs. Subepaulet, wing veins and labella variable.....6. **(Tabaninae)**
2. Third antennal segment of an often ringed but consolidated basal part and four terminal annuli. Proboscis short, seldom much exceeding head height. Mostly small species of less than 12 mm. length and with mottled wings.....**Chrysops**
   Third antennal segment of 7 or 8 distinct annuli; the first two segments never equalling ½ the length of the third. Proboscis often elongate. Larger species mostly over 12 mm.
3. Eyes bare. Face not produced and snout-like, proboscis not longer than hind tibia, generally much shorter. First posterior cell closed; fork of third vein generally with an appendix.....**Esenbeckia**
   Eyes pilose. Face more or less produced and snoutlike. Proboscis longer than hind tibia, often as long as whole insect, more or less extensile, the basal portion coiled within the head capsule.....4
4. Third antennal segment of seven annuli, bipectinate, the first six annuli bearing long dorsal and ventral finger like processes. Brown insects with the first posterior cell of the wing closed and long petiolate..**Pityocera**
   Third antennal segment without such finger-like processes.....5
5. First and fourth posterior cells closed and petiolate. Wings often with dark markings.....**Scione**
   First posterior cell closed or narrowly open, fourth always open. Wings hyaline or smoky, never with prominent dark markings.....**Fidena**
6. Subepaulet without macrotrichia, or the macrotrichia much less dense than on the costa, generally thin and scale-like. Third antennal segment often with a prominent dorsal tooth or long spine. Labella often with shiny sclerotized plates.....7

Subepaulet with macrotrichia similar to those on the costa, often inflated. Dorsal tooth of third antennal segment usually short, rarely reaching beyond first annulus. Labella fleshy, without shiny sclerotized plates....16

7. Basal part of third antennal segment with a strong dorsal angle or minute tooth....8

Basal part of third antennal segment with a strong dorsal tooth or long slender spine....12

8. Labella short, with shiny sclerotized plates. Vertexal tubercle and frontal calli absent in female, the first present in the male. Eyes brownish in life, without irridescent markings. Whole insect green or greenish in life....**Chlorotabanus**

(If frontal callus present, see (*Cryptotylus*).

At least basal frontal callus present. Eyes almost always with irridescent green or purple markings....9

9. Labella with at least small shiny plates at base. Largely black insects with wings partly or largely black. Facial area and palpi swollen, and shiny, or first antennal segment greatly inflated....10

Labella wholly membranous. Tibiae normal, or only the fore pair inflated. Palpi and first antennal segment never as above....11

10. Palpi very broad and flattened, the integument shiny. First antennal segment normal. Thorax and abdomen with bright green metallic scales, **Lepiselaga**

Palpi very slender, pollinose. First antennal segment greatly inflated. Upper branch of third vein turned abruptly forward, joining the costa closer to the second vein than to the wing apex. No green metallic scales....**Bolbodimyia**

11. First antennal segment more or less elongate, usually not less than ⅓ the length of the third segment. Basal part of third segment usually obscurely annulate, sometimes with a blunt dorsal angle. Frontoclypeus usually shiny. Mesopleura pearly pollinose. Subcosta bare above, fifth vein spinose above....**Diachlorus**

First antennal segment short, less than ¼ length of third segment. Frontoclypeus rarely shiny. Mesopleura not pearly pollinose. Subcosta and fifth vein variable. (See also couplet 13)....**Stenotabanus**

12. Third antennal segment with a strong angle or moderately long dorsal tooth which does not reach the first annulus....13

Third antennal segment with a long slender forward pointing spine, which reaches at least to the first terminal annulus....14

13. No vertexal tubercle in either sex. Labella with shiny plates. Whole insect greenish in life, unicolorous....**Cryptotylus**

Vertexal tubercle present, at least in female. Labella without shiny plates, though sometimes small and compact. Whole insect not greenish, generally with contrasting markings....**Stenotabanus**

14. Eyes pilose under a hand lens. Labella small and compact, though not showing shiny plates....**Dicladocera**

Eyes bare under a hand lens. Labella showing shiny sclerotized plates....15

15. Stout, often hairy species; at least the fore tibiae more or less inflated and the hind tibiae with a fringe of long hairs. Antennae rather short and stubby. Palpi inflated....**Stibasoma**

Usually slender species. Tibiae neither inflated nor fringed. Antennae moderate to very long. Palpi slender to almost thread-like..**Dichelacera**

16. All tibiae greatly inflated. Palpi inflated and shiny. Basal portion of third antennal segment nearly 4 times as long as annulate portion. Whole insect shining blue black, only mesonotum greyish pollinose. Subepaulet with sparse macrotrichia in female, none in male....**Selasoma**

Tibiae and palpi normal. Basal portion of third antennal segment seldom if ever twice as long as annulate portion....17

17. At least 3 small but well marked ocelli present. Eyes bare, unicolorous in life. Scutellum and mesonotum with white or yellow hairs, abdomen black or brown, with various white markings....**Leucotabanus**

Without ocelli, with or without a vertexal tubercle. Eyes bare or pilose in one or both sexes....**Tabanus**

CHECK LIST OF THE TABANIDAE OF PANAMA

Subfamily Pangoniinae
Tribe Chrysopini
Chrysops alleni Fairch.
calogastra Schin.
chiriquensis Fairch.
incisa Macq.
melaena Hine
mexicana Krŏb.
soror Krŏb.
variegata (de Geer).
Tribe Pangoniini
Esenbeckia chagresensis Fairch.
illota osornoi Fairch.
prasiniventris (Macq.)
translucens (Macq.)
Fidena fulvosericea Krŏb.
gracilis Krŏb.
howardi Fairch.
isthmiae Fairch.
pyrausta (O. S.)
Pityocera festae Gig.-Tos.
Scione aureopygia Fairch.
claripennis Ricardo.
maculipennis (Schiner).

Subfamily Tabaninae
Tribe Dichelacerini
Dichelacera
(*Dichelacera*) *analis* Hine
marginata Macq.
regina Fairch.
(*Psalidia*) *fulminea* (Hine)
(*Catachlorops*) *transposita* (Walk.)
Dicladocera badia Krŏb.
Stibasoma apicimacula Fairch.
chionostigma (O. S.)
fulvohirtum (Wied.)
theotaenia panamensis Curran
venenata (O. S.)
Cryptotylus limonus (Towns.)
luteoflavus (Bell.)
unicolor (Wied.)
Chlorotabanus inanis (Fab.)
mexicanus (Linn.)
Tribe Lepiselagini
Lepiselaga crassipes (Wied.)
Selasoma tibiale (Fab.)
Tribe Bolbodimyini
Bolbodimyia erythrocephala (Bigot)
Tribe Diachlorini
Diachlorus curvipes (Fab.)
jobbinsi Fairch.
Stenotabanus
(*Stenotabanus*) *calvitius* Fairch.
constabulorum Fairch.
fulvistriatus (Hine)
jaculator Fairch.
lerida Fairch.
maculifrons (Hine)
minusculus (Krŏb)
pequeniensis Fairch.
plenus (Hine)
(*Aegialomyia*) *changuinolae* Fairch.
paitillensis Fairch.
(*Brachytabanus*) *longipennis* Krŏb.
Tribe Tabanini
Leucotabanus canithorax Fairch.
flavinotum (Krŏb.)
leucaspis (Wied.)
Tabanus
(*Tabanus*) *bigoti* Bell.
erebus (O. S.)
ferrifer Walk.
globulicallosus Krŏb.
importunus Wied.
nereus Fairch.
praepilatus Fairch.
rhizophorae Fairch.
rixator Fairch.
umbraticolus Fairch.
(*Bellardia*) *albocirculus* Hine
de-filippii Bell.
piraticus Fairch.
pseudoculus Fairch.
oculus Walk.
(*Hybomitra*) *quadripunctatus* Fab.
(*Neotabanus*) *angustivitta* Krŏb.
amplifrons Krŏb.
dunni Fairch.
enanus Fairch.
fumatipennis Krŏb.
lineola var *carneus* Bell.
var *plangens* Walk.
var *stenocephalus* Hine
maya Beq.
unistriatus Hine
viltiger var *guatemalanus* Hine
(*Philipotabanus*) *chrysothrix* Fairch.
ebrius O. S.
elviae Fairch.
magnificus Krŏb.
medius Krŏb.
pallidetinctus Krŏb.
pterographicus Fairch.

ADDENDA

Since the publication of some of the earlier papers in this series, certain information has come to hand which necessitates a few changes and additions. In the paper on *Dichelacera* and related genera (1940), further study of more material has convinced me that *Psalidia* End. and *Catachlorops* Lutz had best be considered merely as subgenera of *Dichelacera* Macq. As suggested in that paper (p. 693) *Tabanus fulmineus* Hine 1920 is nothing but a dark form of *ocellata* End. 1925 in which the subapical hyaline areas in the wing are almost obsolete, hence the species takes Hine's name. I have examined Hine's types in Columbus, Ohio. *Bellardia furcata* Bigot 1892 is an additional possible synonym for the species. On p. 689 of the same paper *Tabanus umbratus* Hine was suggested as a possible earlier name for *Dicladocera badia* Kröber. I have since seen Hine's type, and it is a quite distinct species of *Catachlorops*. Three additional females of *D. badia* have since been taken (El Valle, Coclé Prov., R. P.), and the wings are somewhat more strongly marked than shown in my figure, which was drawn from a long preserved specimen.

I have also seen specimens of *Tabanus venenatus* O. S. (1 ♀, El Volcan, Chiriqui, R. P., F. E. Lutz coll., and 1 ♂; 1 ♀, near Caracas, Venezuela). It appears to be best placed in the genus *Stibasoma* where it forms a member of a group including *T. planiventris* Wied and *T. viridiventris* Macq. These species are placed by Kröber in *Amphichlorops* Lutz, but the genotype of that genus, *T. flavus* Macq., appears to be much more closely related to *Catachlorops* than it does to the present group. If further study should indicate the desirability of separating this small group of greenish insects from *Stibasoma*, the name *Rhabdotylus* Lutz, with *T. planiventris* Wied. as type is available.

Additional locality records which extend the ranges of two species have also come to hand. *Dichelacera analis* Hine is represented by a female from Rio Curitingua, Nicaragua (Ivan Sanderson coll.), and *T.* (*Neotabanus*) *dunni* Fairch. by a female from the Pacific coast of the same country (W. H. W. Komp coll.).

REFERENCES

Since most of the references to species have been already listed under the various names, only references to catalogues, general works on classification and references not otherwise mentioned in the text are here listed. References to some papers on Neotropical Tabanidae seen by me that have appeared since Kröber's catalogue, which contains a full bibliography to 1934, have also been added.

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BOOK NOTICES

INFORME SOBRE "TUCURAS," by RAFAEL SCHIUMA. 120 pages, 4 colored plates and many text cuts. 1938. Published as Publicacion Miscelanea No. 43 de la Direccion de Sanidad Vegetal, MINISTERIO DE AGRICULTURA, REPUBLICA ARGENTINA. Paper bound.

This volume is a popular handbook on one of the grasshopper pests of Argentina, *Trigonophymus arrogams* Stål. In nine chapters it covers the destructive habits of the pest, its enemies and environmental difficulties, experiments with various poisons and cultural methods of control, and finally outlines a "Plan de accion."—C. H. K.

MOSQUITOES OF THE ETHIOPIAN REGION III. Culicine Adults and Pupae, by F. W. EDWARDS. Pages viii and 499, 4 colored plates, 184 text figs. 7 x 10 inches, cloth. 1941. Published by the BRITISH MUSEUM (Natural History), Cromwell Road, London, S. W. 7, and by BERNARD QUARITCH, LTD., DULAU & Co., LTD., and THE OXFORD UNIVERSITY PRESS.

Edwards died November 15, 1940, it is said from an injury received in a German bombing raid on London. The manuscript for the Mosquitoes of the Ethiopian Region was completed before the author's death. The numerous figures of male genitalia are by his own hand.

Part I of the present volume, pp. 1–353, deals with the Taxonomy of Culicine Adults. Part II, pp. 354–428, covers the Taxonomy of Culicine Pupae. Part III brings up to date (Corregenda and Addenda) the matter dealt with in Volumes I and II of the present work, while Part IV is a discussion of Zoogeography and Ethiopian Mosquitoes.

Edwards was a comparatively young man and, as the specialist on Diptera in the British Museum, had already established a reputation for a great amount of basic work in the taxonomy of that order. His future was bright for many years of just such work. Then suddenly he became a casualty of the war. This magnificent three volume work on African mosquitoes will remind his admirers for many years to come of what he could have accomplished had he lived.—C. H. K.

MEMORIA DE LA COMISION CENTRAL DE INVESTIGACIONES SOBRE LA LANGOSTA, 1934 (publ., 1936), 250 pp., 35 plates and many maps, charts, etc.; 1935 (publ., 1937), 126 pp., 10 plates, maps, etc.; 1936 (publ., 1939), 300 pp., 22 plates (5 colored), maps, etc. Published by the DIVISION DE ZOOLOGIA AGRICOLA, MINISTERIO DE AGRICULTURA, BUENOS AIRES, REPUBLICA ARGENTINA. Cartridge-paper bound.

The three volumes on grasshopper control in northern Argentina reached the Annals office this summer. They are at once an exposition (1) of the enormous size of the problem which covers much of the vast area west and northwest of Buenos Aires, (2) of the thorough mapping and ecological study of the affected area and (3) of the very extensive development of applied entomology in Argentina. In this office we have been prone to judge the level of the development of entomology in any country by the number of subscriptions in that area. The Annals has little South American entomology to offer subscribers "down under," hence the short South American subscription list. Argentina and Brazil have many well developed centers of applied entomology whose staffs of well trained scientists see problems in their broad aspects and who are doing yeoman service in the mastery of insect pests. The three large well printed and beautifully illustrated volumes on the locust problem in Argentina are very worth while exhibits to that effect.—C. H. K.

CORRECTIONS (ERRORS AND OMISSIONS)

Corrections are limited to critical omissions and serious errors.—The Editors.

Sabrosky, Curtis W. 1941. An annotated list of genotypes of the Chloropidae of the world (Diptera). Annals, 34(4): 735–765, December.

The following important errors and omissions have been noted:

p. 738, footnote 3—An additional important item of internal evidence has been discovered in a brief discussion by Loew at the end of his tenth Centuria (1872, Berl. Ent. Ztschr., XVI, p. 113), where he mentions that he had divided the genus *Chlorops* into subgenera in the "Zeitschrift für Entomologie, 1866." While it might be claimed that he merely quoted the title page of the volume, it seems more probable that he would have dated his own genera from 1861 had it actually been the case.

p. 741, line 6—generic name should read CONIOCHLOROPS.

p. 741, line 16 from bottom—heneric name should read CRYPTONEVRA.

Both of these are entirely unintentional emendations, due to overlooked typographical errors.

p. 749—*Cadrema* was actually published in 1859, not 1860 (the imprint date).

p. 751—See footnote 5 for *Crassiseta*.

Clare, Stewart and Oscar E. Tauber. 1942. Circulation of Hemolymph in the Wings of the Cockroach. Annals, 35(1): 57–67:

p. 59. The figures A-E are exchanged with figures A-E on page 62. The legends are correctly placed on pages 59 and 62.

Kennedy, Clarence H. 1942. *Palaemnema lorena* and *P. melanocauda*, New Species, etc. Annals, 35(1): 97–104:

p. 100, line 4—Pacific should be Atlantic.

Hart, Thomas A., 1942. Larval Pilotaxy of *Culex pipiens* with Special Reference to Genetics. Annals, 35(2): 141–142:

p. 145, figures 1 and 2—In legends "dorsal view" should read dorsal and ventral views.

p. 146, figures 3 and 4—In legends "dorsal view" should read dorsal and ventral views.

Fairchild, G. B. 1942. Notes on Tabanidae from Panama, VIII, Annals 35(2): 183–199.

p. 196—*Esenbeckia illota meridionae* should be *Esenbeckia illota meridionale*.

DeLong, Dwight M. 1942. A New Genus (Plumerella) and a New Species of Grass Feeding Leafhopper from Mexico. Annals, 35(2): 200–202.

p. 200—Plumerella should be Plummerella.

Fairchild, G. B. 1942. Notes on Tabanidae from Panama. Annals, 1940–1942.

p. 472, Vol. 35, 1942—See "Addenda" for corrections and notes on the errors and omissions in the series of parts published in these Annals.

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